US Army Corps
of Engineers
St. Paul District

WATER CONTROL MANUAL
LAKE TRAVERSE PROJECT

LAKE TRAVERSE RESERVOIR
LAKE TRAVERSE RESERVOIR AND MUD LAKE RESERVOIR,
INCLUDING RESERVATION DAM AND MUD LAKE DAM

BOIS DE SIOUX RIVER

RED RIVER OF THE NORTH BASIN

MINNESOTA, NORTH DAKOTA AND SOUTH DAKOTA

REVISED DECEMBER 1994

UNCLASSIFIED
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Red River of the North
Bois De Sioux River

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The purpose of this manual is to provide guidance and instruction for project personnel and as a reference source for others who may be involved with or affected by project regulation. The scope of this manual covers all water control management activities as they related to hydraulic and hydrologic aspects of the Lake Traverse project.

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WATER CONTROL MANUAL

LAKE TRAVERSE PROJECT

Lake Traverse Reservoir and Mud Lake Reservoir
Including Reservation Dam and Mud Lake Dam

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

REVISED DECEMBER 1994

CENCS-PE-M

23 December 1994

MEMORANDUM FOR See Distribution

SUBJECT: Lake Traverse - Bois de Sioux River Flood Control Project, Water Control Manual

1. The Lake Traverse - Bois de Sioux River Flood Control Project, Water Control Manual is enclosed for your reference. This manual has been updated in accordance with ER 1110-2-240.

2. Please contact John Blackstone at (612) 290-5429 with comments or to request additional copies.

Encl

for ROBERT F. POST, P.E.
Chief, Engineering and Planning Division

DISTRIBUTION:
CENCD-PE-ED-WH (2 cys)
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DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ARMY CORPS OF ENGINEERS CENTRE
190 FIFTH STREET EAST
ST. PAUL, MN 55101-1638

REPLY TO
ATTENTION OF

December 23, 1994

Management and Evaluation Branch
Engineering and Planning Division

SUBJECT: Lake Traverse - Bois de Sioux River Flood Control Project, Water Control Manual

The Lake Traverse - Bois de Sioux River Flood Control Project, Water Control Manual is enclosed for your reference. This manual has been updated in accordance with Engineering Regulation 1110-2-240.

Please contact John Blackstone at (612) 290-5429 with comments or to request additional copies.

Sincerely,

John J Bailen

Enclosure

Robert F. Post, P.E.
for Chief, Engineering and Planning Division

Distribution of Lake Traverse Water Control Manual 23 December 1994

Organization	Number of Copies	Copy Numbers
North Central Division (CENCD-PE-ED-WH)	2	1 - 2
Water Control (CENCS-PE-H)	12	3 - 14
Project Office (CENCS-CO-PO)	2	15 - 16
Western Area Reservoirs (CENCS-CO-PO)	1	17
Environmental Resources (CENCS-PE-M)	1	18
North Dakota Water Commission 900 East Boulevard Bismark, North Dakota 58505-0187	1	19
South Dakota Department of Water and Natural Resources Room 217 Joe Foss Building Pierre, South Dakota 57501	1	20
Mr. Richard Beringson Secretary South Dakota Department of Game, Fish, and Parks 523 East Capitol Pierre, South Dakota 57501	1	21
Mr. Rod Sando Commissioner Minnesota Department of Natural Resources 500 Lafayette Road St. Paul, Minnesota 55155-4037	1	22
Mayor City of Fargo 200 3rd Street North Fargo, North Dakota 58102	1	23
Mayor City of Moorhead 914 23rd Ave South Moorhead, MN 56560	1	24

Mayor City of Wahpeton City Hall, 524 North Second Wahpeton, North Dakota 58075	1	25
Mayor City of Breckenridge 420 Nebraska Avenue Breckenridge, Minnesota 56520	1	26
North Dakota Department of Health 1200 Missouri Avenue, Box 5520 Bismark, North Dakota 58502-5520	1	27

CENCD-PE-ED-WH (CENCS-PE-M/6 Jun 94) (1110) 1st End
Mr. Krampitz/pz/(312) 353-3131
SUBJECT: Lake Traverse - Bois de Sioux River Flood Control Project, Draft Reservoir Regulation Manual

Commander, North Central Division, U.S. Army Corps of Engineers, 111 North Canal Street, Chicago, IL 60606-7205 2 7 JUL 1994

FOR Commander, St. Paul District, ATTN: CENCS-PE-M

1. The subject report is approved with only discrepancies noted in the elevation datums. For example, there is no 1912 National Geodetic Vertical Datum (NGVD), noted on page XIV. Also, the 1929 datum is incorrectly listed through the report as 1929 NGVD.

2. The HQ, NCD, POC is Mr. Harry Krampitz, CENCD-PE-ED-WH, (312) 353-3131.

FOR THE COMMANDER:

Encls
wd

for DUDLEY M. HANSON, P.E.
Director, Engineering and
Planning Directorate

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
190 FIFTH STREET EAST
ST. PAUL, MINNESOTA 55101-1638

JUN - 6 1994

REPLY TO
ATTENTION OF

CENCS-PE-M

Harry
Retire

MEMORANDUM FOR Commander, North Central Division, River Center Building, 14th Floor, 111 North Canal Street, Chicago, Illinois 60606-7205

SUBJECT: Lake Traverse - Bois de Sioux River Flood Control Project, Draft Reservoir Regulation Manual

1. The subject draft manual is submitted for your review in accordance with ER 1110-2-240. The Operation Plan Evaluation and Environmental Assessment for the Lake Traverse - Bois de Sioux River Flood Control Project has been distributed for agency and public review. Copies of the final report and environmental assessment will be submitted after the Finding of No Significant Impact is signed by the District Engineer in mid-June.

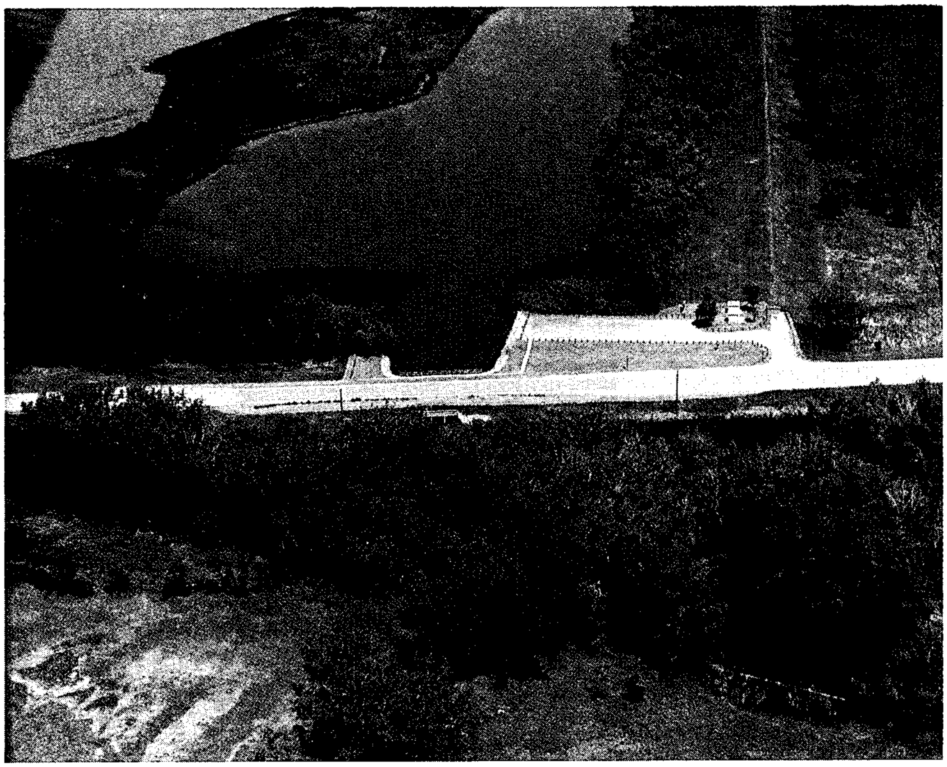
2. The POC for this matter is John Blackstone, (612) 290-5429.

FOR THE COMMANDER:

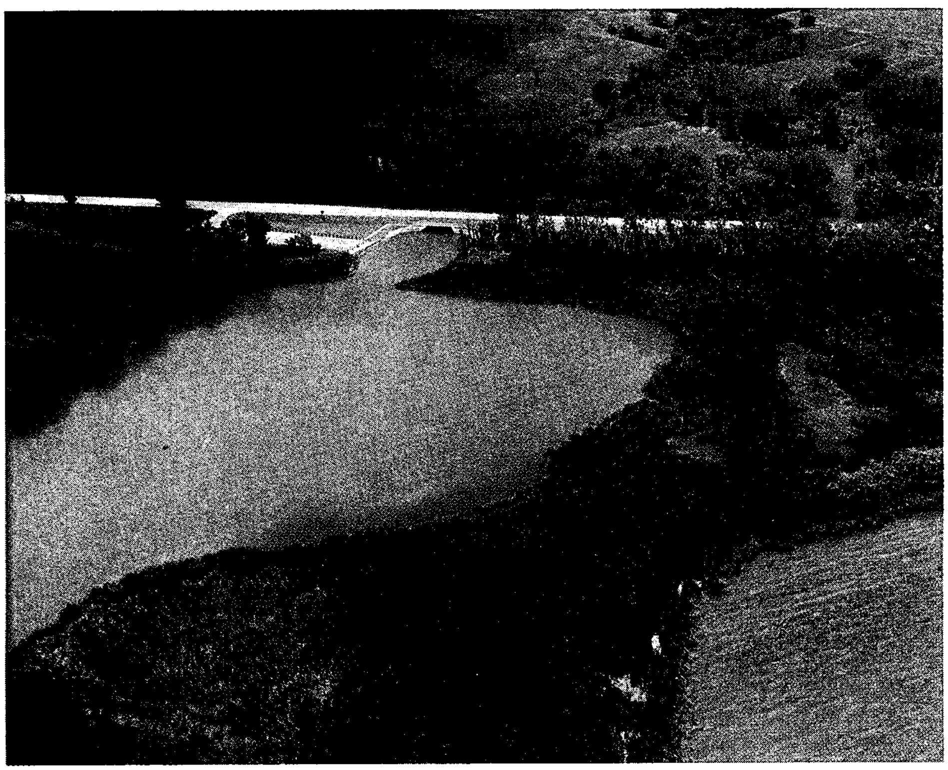
John J Bailey, P.E.

Encls

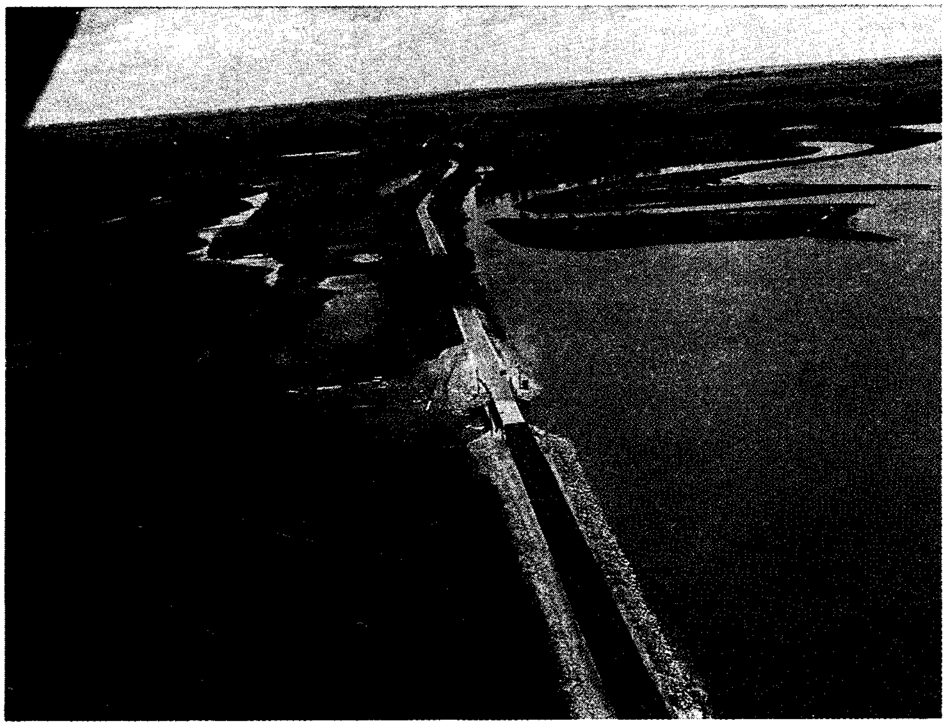
for ROBERT F. POST, P.E.
Chief, Engineering and Planning Division



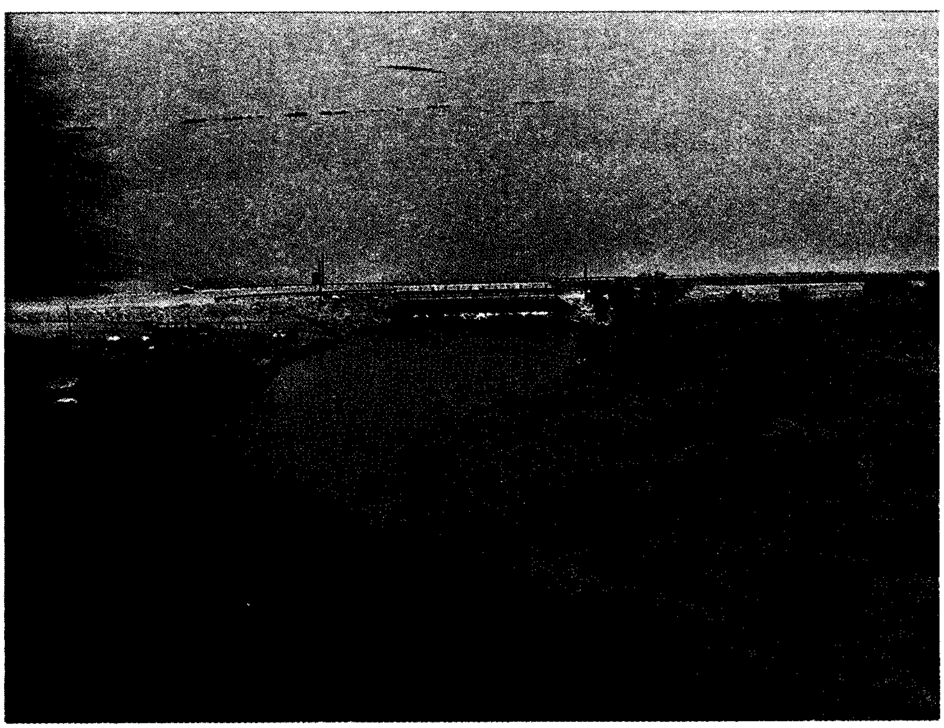
BROWNS VALLEY - UPSTREAM SIDE



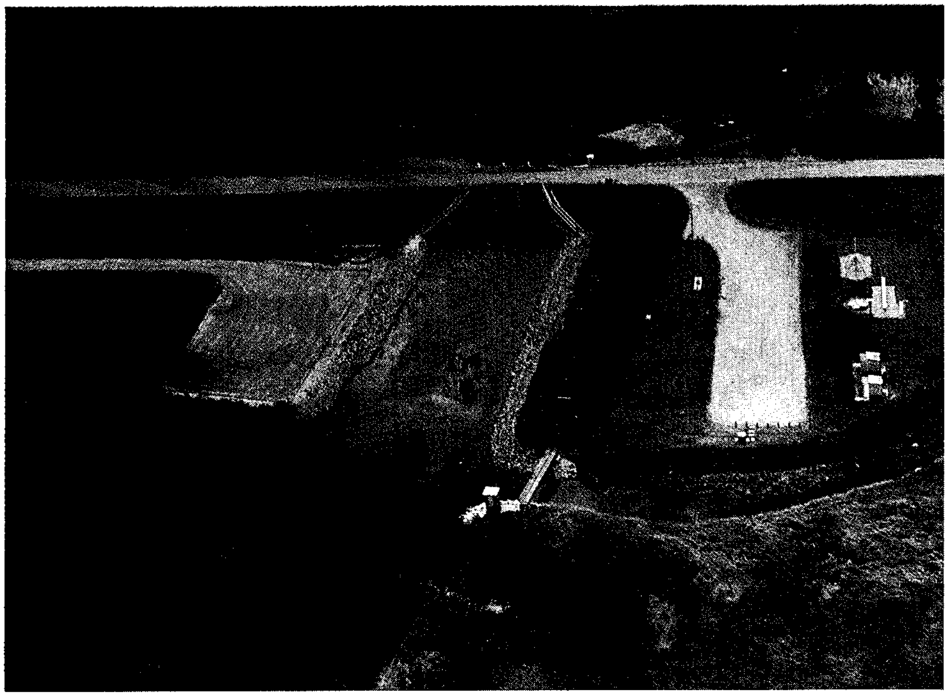
BROWNS VALLEY DIKE - DOWNSTREAM SIDE



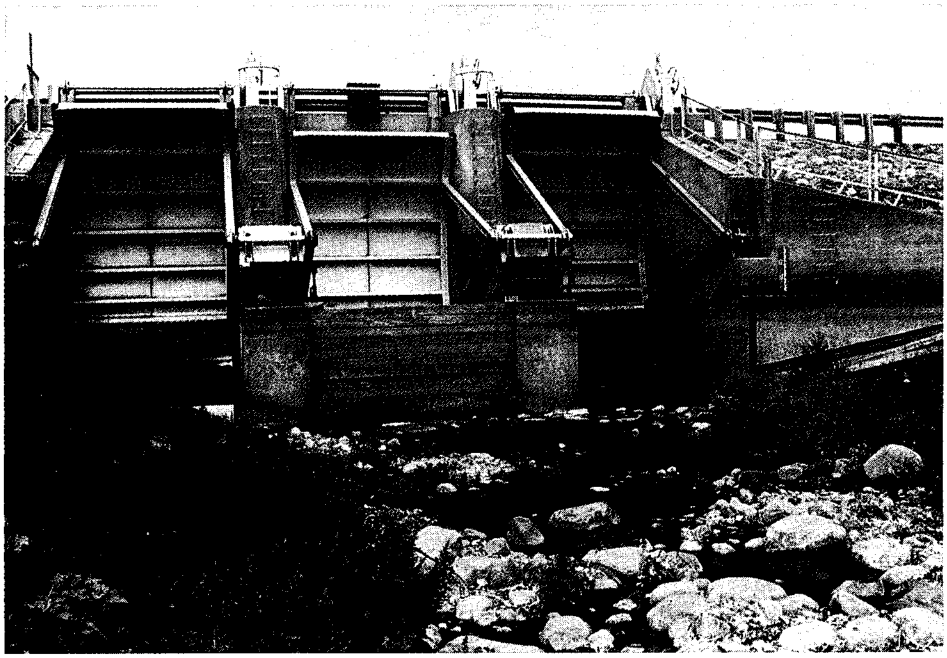
RESERVATION DAM - LOOKING EAST



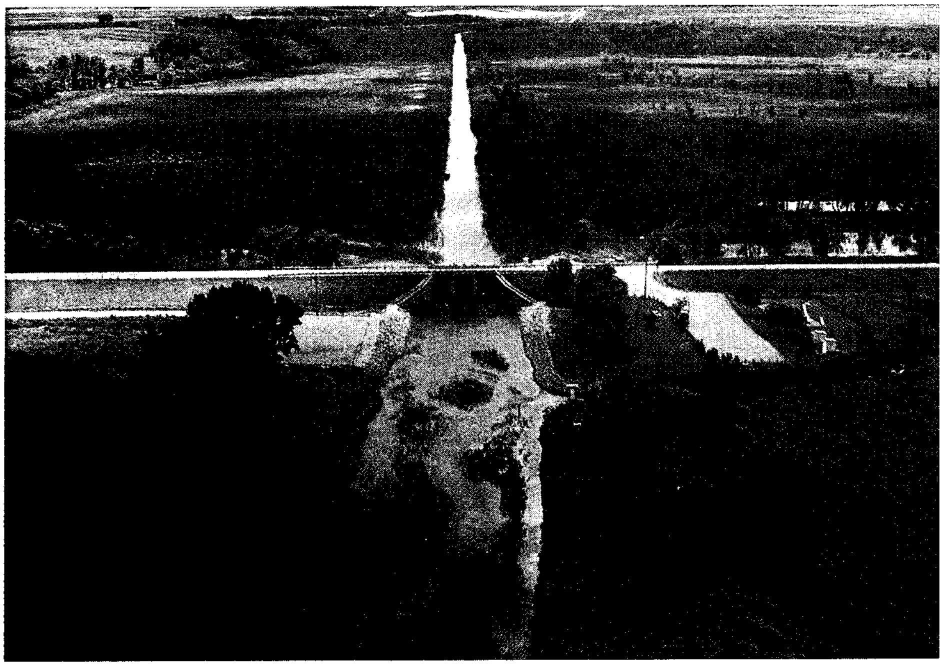
RESERVATION DAM - LOOKING UPSTREAM



WHITE ROCK DAM - LOOKING UPSTREAM



WHITE ROCK DAM - UPSTREAM SIDE OF GATES



WHITE ROCK DAM APPROACH CHANNEL - LOOKING UPSTREAM

BOIS DE SIOUX RIVER CHANNEL - LOOKING DOWNSTREAM

NOTICE TO USERS OF THIS MANUAL

Corps of Engineers regulations specify that this Water Control Manual be published in loose-leaf form to facilitate modifications. In the future, only those sections, or parts thereof, requiring changes will be revised and replaced.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during normal business (duty) hours, contact can be made by telephone to Water Control (612.290.5620) or the District Communication Center's VHF-FM radio (call signal WUD6, Hastings, MN). Water Control's radio call signal is WUD613 (St. Paul, MN). During nonduty hours, assistance can be achieved by contacting, in the order listed, one of the following persons. Their duty hour (work) phone numbers are also listed.

Name		**Number**
Gordon Heitzman	Lake Traverse Project Regulator	Work 612-290-5620 Home 612-772-3150
Fax Number	Hydraulics and Hydrology Branch	Fax 612-290-5841
Edward Eaton	Chief, Water Control Section	Work 612-290-5617 Home 612-754-2640
Bonnie Montgomery	Hydraulic Engineer	Work 612-290-5616 Home 612-450-0905
Kenton Spading	Hydraulic Engineer	Work 612-290-5611 Home 612-488-8893
Helmer Johnson	Chief, Hydraulics and Hydrology Branch	Work 612-290-5602 Home 612-633-7791
Robert Post	Chief, Engineering and Planning Division	Work 612-290-5303 Home 612-437-1316

Lake Traverse Project
Bois de Sioux River

U. S. Army Corps of Engineers
St. Paul District
Revised December 1994

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VIII - EFFECT OF WATER CONTROL PLAN

TABLES

PLATES

PLATES (continued)

EXHIBITS

Note: A detailed table of contents is included with Exhibit D.

MEAN SEA LEVEL REFERENCE DATUM

All elevations in this manual use the 1912 Mean Sea Level adjustment (1912 MSL) unless otherwise stated.

METRIC EQUIVALENTS AND CONVERSIONS

Length:

1 centimeter = 0.394 inch
1 meter = 3.28 feet
1 kilometer = 0.621 mile

Area:

1 $meter^2$ = 10.764 $feet^2$
1 $kilometer^2$ = 0.386 $mile^2$
1 hectare = 2.471 acres

Volume:

1 $meter^3$ = 35.31 $feet^3$
1 $meter^3$ = 1.308 $yards^3$
1 $meter^3$ = 0.81×10^{-3} acre-feet

Flow:

1 $meter^3$/second = 35.31 $feet^3$/second

Temperature:

(Fahrenheit - 32)/1.8 = Degrees Celsius

PERTINENT DATA
LAKE TRAVERSE PROJECT
WHITE ROCK DAM/MUD LAKE -- RESERVATION DAM/LAKE TRAVERSE

General: Project Location: Traverse County, Minnesota, and Roberts County, South Dakota, Headwaters of the Bois de Sioux River, 30 Miles South of Wahpeton, North Dakota, Latitude 45° 51′ 45", Longitude 96° 34′ 25" (White Rock Dam)

Drainage Area Above White Rock Dam	1,160 square miles
Uncontrolled Drainage Area Above the Wahpeton, North Dakota Control Point	1,020 square miles

Dam:	**White Rock Dam**	**Reservation Dam**
Type:	Rolled-Earth Fill	Rolled-Earth Fill
Length:	14,400 Feet	9,100 Feet
Height:	16 Feet	14.5 Feet
Top Width:	26 Feet (roadway)	26 Feet (roadway)
Freeboard:	4 Feet (above SDF[1])	Not Applicable
Volume of Dam:	329,200 Cubic Yards	188,000 Cubic Yards

Spillway:		
Type:	Reinforced Concrete	Grouted Riprap Weir
Length:	3-16′Hx13′W Reversed Tainter Gates	15 Stoplog Bays, 7′H x 6′W[2] 2 Stoplog Bays, 7′H x 5′9"W[2]
Design Flood:	5,600 cfs	5,600 cfs
Invert Elev.:	965.00 Feet	974.00 Feet

Reservoir/Capacities/Areas:

White Rock Dam/Mud Lake	**Elevation Feet**	**Capacity Ac-Ft**	**Area Acres**
Sill	965.00	0	
Conservation Pool	972.00	6,500	3,850
Top of Flood Control Pool	981.00	249,500	22,975
Maximum Pool	982.00	273,000	23,425
Flowage Easement Level	983.00	296,000	23,850
Top of Dam	986.00	368,000	24,800
Reservation Dam/Lake Traverse			
Sill	974.00	84,000	10,150
Conservation Pool	976.00	106,000	10,925
Top of Stop Logs	976.80	115,000	11,200

Note: The two pools become one pool at approximately elevation 976.8 feet. The control shifts to White Rock Dam.

1. SDF = Spillway Design Flood
2. Clear opening width

I - INTRODUCTION

1-01. Authorization. This manual was prepared in compliance with: Engineering Regulation 1110-2-240 titled "*Water Control Management*" dated 8 October 1982. It supersedes the previous manual (dated June 1963) and incorporates changes to the water control plan recommended in the Reservoir Operation Plan Evaluation (ROPE) report dated April 1994. The previous reservoir regulation manual was prepared in accordance with authorization from the Office, Chief of Engineers dated 15 May 1942 and 8 May 1951.

1-02. Purpose and Scope. The purpose of this manual is to provide guidance and instruction for project personnel and as a reference source for others who may be involved with or affected by project regulation. The manual is for daily use in water control activities for essentially all foreseeable conditions. The scope of this manual covers all water control management activities as they relate to the hydraulic and hydrologic aspects of the project.

Guidance on the purpose and scope of this manual was extracted from Engineering Circular 1110-2-278 titled "*Preparation of Water Control Manuals*" dated 31 August 1993, and Engineering Manual 1110-2-3600 titled "*Management of Water Control Systems*" dated 30 November 1987.

1-03. Related Manuals and Reports. Prior reports on flood control and improved navigation for the region date from 1849. Some of the information is included in annual reports of the Chief of Engineers. A list of some of the reports follows. Additional reports are listed in **Exhibit B.**

a. *Report on a comprehensive water plan drawn by the Interstate planning boards of Minnesota, North Dakota, and South Dakota*, Corps of Engineers, 2 July 1937. This report was prepared by the Corps of Engineers at the request of the Work Progress Administration.

b. *Lake Traverse-Bois de Sioux River Flood Control and Water Conservation Project*, Corps of Engineers, St. Paul District, 1 March 1941. This report discusses the development of the existing project.

c. *Diversion of Floodwaters of Little Minnesota River into Lake Traverse*, U.S. Engineer Office, St. Paul, Minnesota, 17 September 1945.

d. *Lake Traverse Reservoir and Bois de Sioux River, Channel Improvement, Reservoir Regulation Manual*, U.S. Army Engineer District, St. Paul, Minnesota, Corps of Engineers, June 1963.

e. *Orwell Dam and Reservoir, Reservoir Regulation Manual*, U.S. Army Engineer District, St. Paul, Minnesota, Corps of Engineers, April 1954 (revised August 1963).

f. *Reconnaissance Report for Dam Safety Assurance Program, Lake Traverse*, U.S. Army Corps of Engineers, St. Paul District, September 1983.

g. *Orwell Reservoir Operation Plan Evaluation and Environmental Assessment*, U.S. Army Corps of Engineers, St. Paul District, January 1986.

h. *Problem Appraisal Report, Operation Plan Evaluation, Lake Traverse*, U.S. Army Corps of Engineers, St. Paul District, January 1987.

i. *Emergency Plan, White Rock Dam and Lake Traverse*, Dam Safety Program, Lake Traverse Project, Corps of Engineers, St. Paul District, October 1989.

j. *Drought Contingency Plan, Lake Traverse Reservoir Regulation Manual Appendix (draft)*, U.S. Army Corps of Engineers, St. Paul District, September 1992.

k. *Operation Plan Evaluation and Environmental Assessment, Lake Traverse, Bois de Sioux River and Orwell Reservoir*, U.S. Army Corps of Engineers, St. Paul District, April 1994.

l. *Ice Influenced Flood Stage Frequency Analysis - Red River of the North and Bois de Sioux River at Wahpeton, North Dakota, and Breckenridge, Minnesota*, U.S. Army Corps of Engineers, St. Paul District, October 1990.

1-04. Project Owner. The U.S. Army Corps of Engineers, St. Paul District is responsible for the regulation of the Lake Traverse Project. The United States Government is the owner of the project.

1-05. Operating Agency. The U.S. Army Corps of Engineers, St. Paul District, Construction-Operations Division, Natural Resource Management Branch, is responsible for the operation and maintenance of the Lake Traverse Project. Regulation instructions for the project are provided by the Water Control Section, Hydraulics and Hydrology Branch, Engineering and Planning Division. The project is attended continuously during normal business hours. A 24-hour recording can be reached by telephone to obtain current project information (see below). The Resource Manager also operates Orwell Dam. The Area Resource Manager's office is in Fargo, North Dakota. The Project Resource Manager and his assistant and the Area Manager can be reached at the following numbers:

Table 1-1

Project Office Points of Contact

Name	Number
David Salberg, Project Resource Manager	Work 612-563-4586 Home 612-563-4586 VHF Radio WUD638
David Doll (assistant)	Work 612-563-4586 Home 612-563-4075
Project Fax Number	612-563-8662
24-Hour Project Information Recording	612-563-8681
Timothy Bertschi, Area Resource Manager	Work 701-232-1894 Cellular 701-238-1680 VHF Radio WUD642

1-06. Regulating Agency. The regulation of the Lake Traverse Project is under the supervision of the Water Control Section, within the Hydraulics and Hydrology Branch, Engineering and Planning Division, of the St. Paul District, Corps of Engineers.

II - DESCRIPTION OF PROJECT

2-01. Location. The Lake Traverse Flood Control Project is on the boundaries of Minnesota, North Dakota and South Dakota. The project lies within Traverse and Wilkin Counties, Minnesota, Richland County, North Dakota, and Roberts County, South Dakota (**Plate 2-1**). Lake Traverse forms the headwaters of the Bois de Sioux River. The project extends from the continental divide at Browns Valley, Minnesota, to a point along the Bois de Sioux River 6 miles south of Wahpeton, North Dakota, and Breckenridge, Minnesota (**Plate 2-2**).

The Browns Valley Dike is approximately 16.5 miles south of Reservation Dam at the upper end of the project near Browns Valley, Minnesota. Reservation Dam, at Minnesota Highway No. 117 (sometimes called Reservation Highway), forms the Lake Traverse Reservoir when the pool is below elevation 976.8 feet. This structure is located approximately 7.5 miles south of White Rock Dam. The channelized portion of the Bois de Sioux River extends from White Rock Dam north 24 miles to a point 6 miles south of Wahpeton, North Dakota, and Breckenridge, Minnesota.

2-02. Purpose. The Lake Traverse Project was authorized by the Flood Control Act of 22 June 1936 (Public Law 74-738). The Act authorized flood control and water conservation as project purposes. The above, and other project purposes assigned by Congress following completion of the project, are listed in **Table 2-1.**

Table 2-1 Lake Traverse Project Authorized Purposes Assigned by Congress		
Authorized Purpose	**Public Law No.**	**Description**
Flood Control and Water Conservation	74-738	Flood Control Act of 1936
Recreation and Surplus Water	78-534	Flood Control Act of 1944
Fish and Wildlife	85-624	Fish and Wildlife Coordination Act of 1958
Water Supply	85-500	Water Supply Act of 1958
Recreation	89-72	Federal Water Project Recreation Act of 1965
Water Quality	92-500	Federal Water Pollution Control Act Amendments of 1972
	95-217	Clean Water Act of 1977
Fish and Wildlife	93-205	Conservation, Protection, and Propagation of Endangered Species Law of 1973

2-03. Physical Components.

a. General. The Lake Traverse Project consists of: the Browns Valley Dike, Reservation and White Rock Dams and associated reservoirs, and the Bois de Sioux River channel **(Plate 2-1)**.

The Browns Valley Dike, at the head of Lake Traverse, was originally built to prevent interbasin flow to/from the reservoir across the continental divide. Later, a culvert was placed through the dike.

The reservoir behind Reservation Dam is named Lake Traverse. Reservation Dam can only control outflow to a maximum elevation of approximately 976.8 feet (top of the stop logs). When the pool exceeds that elevation, it spills into Mud Lake.

Mud Lake is the reservoir behind White Rock Dam and immediately downstream of Reservation Dam. When Mud Lake reaches an elevation of 976.8 feet, the level of Lake Traverse, Mud Lake and Lake Traverse become essentially one pool and the control shifts to White Rock Dam.

The Bois de Sioux River channel provides the necessary channel capacity for the drawdown of the Lake Traverse Project.

All of the above items, including the Browns Valley Dike, the two dams, the reservoirs, and the Bois de Sioux Channel, are called the Lake Traverse Project.

b. Browns Valley Dike. The dike extends for a distance of 3,700 feet between South Dakota State Trunk Highway 10 (which is also Minnesota State Trunk Highway 28) and Minnesota Highway 27. The dike is constructed of rolled earth fill and has a top width of 10 feet and a top elevation of 987.0 feet. The side slopes above elevation 981.0 feet are 1 on 4 on both sides. On the lake side, below elevation 981.0 feet, the side slope is 1 on 15. A general plan and cross sections are shown on **Plate 2-3**.

A raised section of South Dakota Highway 10/Minnesota Highway 28, along with a concrete box culvert through the dike, diverts overbank flows from the Little Minnesota River into Lake Traverse to prevent flooding the village of Browns Valley. Conversely, when Lake Traverse is high, water from the reservoir can flow south.

The culvert structure is under South Dakota Highway 10 and is divided into three, 6-foot by 9-foot openings. The culverts are 68 feet 9 inches long. The invert elevations on the lake or east side and on the west side are at elevations 974.0 and 971.0 feet, respectively. The culverts were installed in the dike after the Lake Traverse Project was completed.

c. **Reservation Dam.** The dam is topped by Minnesota Highway No. 117 (Reservation Highway) which crosses the narrows between Lake Traverse and Mud Lake. The dam/highway embankment is rolled-earth fill and has a total volume of about 188,000 cubic yards. The highway surface is bituminous concrete (blacktop) and the embankment side slopes are riprapped. The highway crosses the South Dakota/Minnesota State boundary. A general plan and cross section are shown on **Plate 2-4.**

The embankment on the Minnesota side is about 9,100 feet long and has a top elevation of 981.0 feet ($\pm$ 0.5 foot) thereby providing additional spillway capacity during floods when the reservoir elevation exceeds approximately 980.5 feet. The upstream side slope is 1 on 6 and the downstream slope is 1 on 8.

The embankment on the South Dakota side is about 1,100 feet long and has a top elevation of 983.0 feet which is 1 foot above the maximum flood of record. On the South Dakota side, the side slopes are 1 on 4 upstream and 1 on 3 downstream.

d. Reservation Dam Outlet Structure. The Reservation Dam outlet structure is a grouted riprap weir with a spillway crest elevation of 974.0 feet. It has a 15-foot-long steel sheet piling cutoff wall. The abutments use 20-foot-long steel pilings. A general plan and cross section are shown on **Plate 2-4.**

There are 17 stop log sections (bays) across the top of the spillway. The bays are separated by 8-inch steel "H" columns which are 20 feet long. The "H" columns form the support for a walkway over the spillway and provide the means of placing or removing the wooden stop logs. To prevent loss of water due to wind action, 6 stop logs are stacked to elevation 976.8, 0.8 foot above the conservation pool elevation of 976.0 feet. The spillway is made up of 18-inch derrick stone. The bottom 9 inches are filled with gravel and the top 9 inches are filled with concrete. The downstream face of the weir has a slope of 1 on 2.5. The total length of the spillway is 27.5 feet with a maximum width of 150 feet.

Two metal culverts 24 inches in diameter and 14 feet long were placed under the spillway for low flow control. The culverts have slide gates and the inverts are at elevation 970.0 feet. These culverts are no longer operational. The slide gates have been removed and removable plugs inserted in the inlets. Riprap has also been placed to prevent the plugs from coming out.

An aluminum bulkhead has been fabricated to replace the wooden stop logs in one bay. The bulkhead was constructed as an experiment to see if leakage from the dam could be reduced. Although the bulkhead is effective, additional bulkheads have not yet been constructed for the other stop log bays.

Elevation-discharge rating curves for the individual gates in the structure with all stop logs removed are shown on **Plate 2-5.**

e. White Rock Dam. The White Rock Dam is a 14,400-foot-long rolled-earth fill embankment. This length includes the concrete control structure which is 47 feet long. The embankment has a total volume of 329,200 cubic yards and a top elevation of 986.0 feet. The upstream and downstream embankment side slopes are 1 on 2.5 and 1 on 2, respectively. The entire upstream slope is covered with a 6-inch gravel blanket topped with 12 inches of riprap. Only the base of the downstream slope is covered with riprap which is also 12 inches deep. The top width of the dam is 26 feet and carries a roadway connecting U.S. Highway 81 in South Dakota and Traverse County Highway No. 10 in Minnesota. A general plan and cross section are shown on **Plate 2-6.** Discharge characteristics of the dam are discussed in detail in **Paragraph 4-09** of this manual.

f. White Rock Dam Outlet Structure. The White Rock Dam outlet structure is a reinforced concrete section topped with a bridge deck. The structure contains three reversed Tainter gates. Each gate is 13 feet wide by 16 feet high with a sill elevation of 965.0 feet. The two middle piers are each 4 feet wide, making the total distance between the abutments 47 feet. The Tainter gates are supported by trunnions attached to the 4-foot-wide middle piers and the abutments. The gate operating machinery is located on top of the piers. The gate machinery contains a worm gear drive system with speed reducers which utilize a 42 to 1 reduction. The machinery is operated manually. In the closed position, the top of the gates is at elevation 981.0 feet or 9 feet above the normal conservation pool elevation of 972 feet. The capacity of the structure at pool elevation 981.0 and 982.0 feet is 4,000 c.f.s. and 5,600 c.f.s., respectively. A general plan and cross section are shown on **Plate 2-6.** An elevation-discharge rating curve for the structure, with all the gates raised clear of the water surface, is shown on **Plate 2-7.**

During periods of low flow and winter operation, the two outer Tainter gates are closed and a bulkhead is installed in the center stop log slot. The middle Tainter gate is left open. A 2-foot-diameter low-flow gate in the center bulkhead allows metering of

low flows up to about 40 cubic feet per second. Stop logs can be inserted into the outer bays during an emergency, or in the fall to prevent the outer Tainter gates from freezing shut. A general plan and cross section of the low-flow gate are shown on **Plate 2-8.**

g. White Rock Dam Stilling Basin. The White Rock Dam stilling basin is 34.07 feet long and 47 feet wide. The floor of the basin is at elevation 960.0 feet. Baffles, with a top elevation of 964.0 feet, are arranged in two rows approximately 8.0 feet apart and extend across the entire width. A stepped sill, with a top elevation of 963.0 feet, is provided at the downstream end of the basin to stabilize the jump. Flared wing walls extend out from the downstream end. The basin is designed to produce a hydraulic jump for the dissipation of energy. A general plan and cross section are shown on **Plate 2-6.**

h. White Rock Dam Approach Channel. The approach channel to the control structure is approximately 2 miles long with a bottom elevation of 966.0 feet. The channel was originally excavated to provide a free flow from the open water portion of Mud Lake to the dam. The approach channel silted in, however, following completion of the project. It was excavated again in 1989 as part of the Mud Lake Waterfowl Habitat Management Plan to allow the lake/marsh to be drawn down for vegetation management. Material removed from the channel was used to build a series of islands for waterfowl nesting.

i. Bois de Sioux River Channelization. The Bois de Sioux River was straightened and enlarged to form an outlet channel for White Rock Dam. The channelized reach stretches for approximately 24 miles from the dam to about 5 miles south of the sister cities of Wahpeton, North Dakota, and Breckenridge, Minnesota. The channel bottom is 60 feet wide with side slopes of 1 on 3. The longitudinal slope from White Rock Dam to the mouth of the Rabbit River is about 0.5 foot per mile. This section is designed to carry 1,100 cubic feet per second with 1 foot of freeboard. From the mouth of the Rabbit River to the end of the project, the longitudinal slope is about 0.06 foot per mile with a capacity of 2,000 cubic feet per second. A general plan and a typical cross section are shown on **Plate 2-9**.

j. Reservoirs. Lake Traverse Reservoir is about 16.5 miles long from Reservation Dam to the dike at Browns Valley and it averages about 1.25 miles in width. At the project conservation pool elevation of 976.0 feet, the capacity is 106,000 acre-feet. White Rock pool is about 7.25 miles in length and stretches between White Rock Dam and Reservation Dam. At the project conservation elevation of 972.0 feet, the capacity is 6,500 acre-feet. The total flood storage capacity for both pools at elevation 981.0 feet

is 249,500 acre-feet. See **Paragraph 2-01** for additional information about the pools. **Plate 2-1** contains a project map. For reservoir elevation-area and elevation-capacity data, see **Plates 2-10 and 2-11.** Bathymetric maps of Lake Traverse are shown on **Plates 2-12 and 2-13.**

2-04. Related Control Facilities.

a. General. The Mustinka River, Twelve Mile Creek, and Traverse County Ditch No. 42 channelization projects are not part of the Federal flood control project. They were constructed by State and local interests.

b. Mustinka River Channelization and Mustinka State Ditch. The Mustinka River flows into Lake Traverse just above Reservation Dam. The Mustinka River basin contains approximately 75 percent of the drainage area upstream of the reservoir. Channel modifications have been made in the basin to decrease the runoff time.

Approximately 20.6 miles of the Mustinka River were straightened and deepened, which increased the discharge capacity from 830 cubic feet per second to 2,140 cubic feet per second. In addition, the Mustinka State Ditch was constructed which parallels the river between State Highway No. 9 and Traverse County Road No. 11. The ditch intersects Twelve Mile Creek and Five Mile Creek.

The project was designed to provide capacity for floods with a 10-year recurrence interval with a minimum of 1 foot of freeboard. A general plan and a typical cross section are shown on **Plate 2-14.**

c. **Twelve Mile Creek Channelization.** Twelve Mile Creek is a tributary to the Mustinka River. Twelve Mile Creek was straightened and enlarged from its intersection with the Mustinka River Ditch to State Highway No. 27. The creek's discharge capacity was increased from 1,420 cubic feet per second to 1,615 cubic feet per second. The project was designed to provide capacity for floods with a 10-year recurrence interval with a minimum of 1 foot of freeboard. A general plan is shown on **Plate 2-14.**

d. **Traverse County Ditch No. 42.** Traverse County Ditch No. 42 connects Five Mile Creek and Twelve Mile Creek. The ditch was enlarged to increase its discharge capacity from 385 cubic feet per second to 400 cubic feet per second. The project was designed to provide capacity for floods with a 10-year recurrence interval with a minimum of 1 foot of freeboard. A general plan is shown on **Plate 2-14.**

2-05. Real Estate Acquisition.

a. Reservoirs. During the period 1940 to 1945, approximately 1,144 acres of fee title and 6,172 acres of flowage easement were acquired by the Federal Government for the Lake Traverse Project. The fee title areas were obtained for construction of the two dams, maintenance areas, and public day-use facilities. The easement areas were needed for the flood control pool. In addition, 217 acres of additional lands were formed by reliction; i.e., area exposed by falling lake levels, delta formation, or other geomorphologic processes. The easement and fee title areas are shown on **Plates 2-15 and 2-16.**

Of the total project lands: 880 acres are leased to the Minnesota Department of Natural Resources (MDNR) for wildlife management, 640 acres are in a Corps-managed wildlife area, and 10 acres are leased to Traverse County for recreation. Most of the land leased to the MDNR is adjacent to Reservation Dam/Minnesota Highway No. 117 and consists of marsh, upland prairie, and stands of willow and cottonwood. The MDNR also leases 7.5 acres near Browns Valley Dike for a boat access area. The Corps of Engineers public use areas at Browns Valley Dike, Reservation Dam, and White Rock Dam use approximately 5 acres.

Prior to construction of the project, the natural water levels tended to fluctuate around the conservation pool elevation of 976.0 in Lake Traverse (sometimes called Reservation pool, or south pool) and the conservation pool elevation of 972.0 in Mud Lake (sometimes called White Rock pool, or north pool). The lakes were dry for several seasons during the 1930's "Dust Bowl" years. The land below the ordinary (or "conservation") pool elevations was determined to be meandered lands and thus already in public (State) ownership. The Federal Government acquired easements on lands between the conservation pool elevations for the two pools (972 and 976 feet) and elevation 983.0 feet.

The following two paragraphs were taken from the actual flowage easement documents for each affected property. The originals are recorded in the appropriate county land offices.

SOUTH POOL (LAKE TRAVERSE) Conservation Pool Elevation 976.0 (Situated between Reservation Highway and Browns Valley Dike)

> The full, complete, and perpetual right, power, and privilege to overflow those lands lying below elevation 977.0 m.s.l. (1912 adj) and also the full, complete, and perpetual right, power, and privilege to overflow intermittently those lands lying between the taking line and elevation 977.0 m.s.l. (1912 adj), together with the right to go upon the lands, as occasion may require, to remove therefrom natural or artificial structures or obstructions which may be detrimental to the operation and maintenance of the dams and reservoirs.

NORTH POOL (MUD LAKE) Conservation Pool Elevation 972.0 (Situated between Reservation Highway and White Rock Dam)

> The full, complete, and perpetual right, power, and privilege to overflow intermittently each and all of the lands involved, together with the right to go upon the lands, as occasion may require, to remove therefrom natural or artificial structures or obstructions which may be detrimental to the operation and maintenance of the dams and reservoirs.

The taking line mentioned in the flowage easement wording was established using a metes and bounds description. The metes and bounds description of the flowage easement taking line was also recorded at the appropriate county land offices. Metes and bounds descriptions use wording involving a series of distances and angles from a known point that exactly and permanently describes the boundary line for the Federal flowage easement. The metes and bounds taking line was established by generally following the contour of elevation 983.0 where it was located at the time of being established. Flowage easement corner monuments were not established at the time of the flowage survey. Boundary lines that are described by metes and bounds can be reestablished on the ground by qualified land surveyors. Maps of the metes and bounds description are available in the St. Paul District map files.

In May 1987, the St. Paul District recorded a new document in Roberts and Traverse County land offices to explain the extent of the taking line for the flowage easements. The document describes the taking line as following the elevation 983 foot contour as a guide. The document is intended to help clarify the taking line metes and bounds description. The newly recorded document is intended to appear with all new abstracts and with all old abstracts every time they are updated.

b. Bois de Sioux River Channelization. The Congressional authorization for the 24-mile-long Bois de Sioux River channel project established that the Federal Government is responsible for construction and maintenance of the channel. The Corps of Engineers has rights within the project boundaries to excavate and remove land for the construction and maintenance of the project and to deposit the excavated material.

The real estate interest for the construction and maintenance of the channel project is in the form of easements within specific project boundaries. The project boundaries are defined by metes and bounds descriptions. The easement strip established for the channel construction and maintenance averages approximately 500 to 600 feet in total width including both sides of the channel. Maps of the metes and bounds description are available in the St. Paul District map files. The easement and fee title areas are shown on **Plate 2-16.**

2-06. Public Facilities.

a. Browns Valley Dike. The public use facilities at Browns Valley Dike consist of a picnic area, shoreline fishing access, and privies **(Plate 2-17)**.

b. Reservation Dam. The facilities at Reservation Dam consist of a picnic area, shoreline fishing access, privies, playground, and a boat ramp for access to Mud Lake **(Plate 2-18)**.

c. White Rock Dam. The facilities at White Rock Dam consist of a picnic area/shelter, shoreline fishing access, handicapped-accessible privies, playground, and drinking water **(Plate 2-19)**.

d. Other. There are nine Corps-managed wildlife areas on the project (640 acres total) which are open to the public. Boating access to Lake Traverse is also available through the Mustinka County Park (in Traverse County) and at various sites along both sides of the lake. The Mustinka Park is located approximately 1 mile east of Reservation Dam.

III - HISTORY OF PROJECT

3-01. Authorization. The Lake Traverse Project, on the Bois de Sioux River, was authorized by the Flood Control Act of 22 June 1936. The Flood Control Act of 28 June 1938 made two modifications to the previous act: 1.) local interests were relieved of the responsibility for acquisition of lands and payment of damages in connection with the project; and 2.) operation and maintenance of the project became the responsibility of the Federal Government.

3-02. Planning and Design. Waterways provided the easiest means of transportation in the 18th, 19th and early 20th centuries when the Minnesota and Dakota Territories were being settled. Lake Traverse provided a vital link in the 1800's, as a waterway connecting the Minnesota territory with Canada. The Minnesota River and the Red River of the North were used by the traders, trappers, and explorers to reach the settlements of Canada and points in between. The most extensively used route followed the Minnesota River from St. Paul to Big Stone Lake, thence overland into Lake Traverse and down the Bois de Sioux River to the Red River. If the Little Minnesota River was flooding (usually April to June), the entire journey could be made by boat. There are reports of light-draft steamboats making the entire trip from St. Paul to Winnipeg. However, obstructions in the channel along the upper Minnesota River made the passage of large craft a hazardous undertaking.

All of the early engineering surveys and examinations of the area were directed toward navigation. Most of the recommendations involved dredging and the removal of obstructions in the channels to improve navigation. The construction of reservoirs was not recommended in the early reports, due to the lack of economic benefits derived from improved navigation.

As the population of the region grew and development began to occur, other problems surfaced. Flood control, in particular, became a concern as cities sprouted up along the streams and the rich bottomlands along the rivers were converted to agricultural uses.

Interest in the development of flood control projects in the Lake Traverse and Big Stone Lake area began in the early 1900's. The Department of Agriculture published a report in 1922 on drainage and prevention of overflow in the Red River of the North Valley. This study discussed features that are very similar to some of those incorporated in the existing project. The Administration of Public Works requested, in 1933, that the Chief of Engineers report on an application, which was developed from the 1922 report, for flood control works on Lake Traverse and the Bois de Sioux River. The District Engineer determined that the proposed plan set forth in the application was adequate in its engineering aspects and was economically justified. No local entity existed to

undertake the construction, operation, and maintenance of the proposed project. (A local sponsor is required for the Government to undertake a project.) The formation of the Tri-State Waters Commission by the States of Minnesota and North and South Dakota provided the necessary local cooperation. The Tri-State Commission, along with the enactment of the 1936 Flood Control Act, made Federal participation in the project possible.

3-03. Construction. Construction of the Lake Traverse Project began in the latter part of 1939, and the project was completed in 1942.

3-04. Related Projects. The Orwell Dam and Reservoir, located on the Ottertail River in Minnesota, is also used to reduce flooding in the Wahpeton, North Dakota, and Breckenridge, Minnesota, area. Refer to the Orwell Dam and Reservoir Regulation Manual for information on that project. **Plate 2-2** shows the location of Orwell Dam.

3-05. Modification to Regulations. The original plan of regulation set the conservation pool elevation for Lake Traverse at 977.0 feet. After experiencing three months of reservoir levels near elevation 977.0 feet, during the first year of operation in 1942, local interests requested that the conservation pool be lowered to 976.0 feet. This change was authorized by the Office of the Chief of Engineers and implemented in September 1942.

Following three years of low water in 1961, local interests again suggested a change in the regulation plan, requesting that Lake Traverse's pool elevation be held above 976.0 feet. The District Engineer authorized the addition of one log to each stop log bay in Reservation Dam, resulting in a conservation pool elevation of 976.4 feet. After low water levels were experienced in 1974, as a result of spillage due to high winds, local residents once more called for the lake level to be raised. An additional row of stop logs was added to each bay to ensure lake levels would not fall below elevation 976.4 feet due to wind-induced water loss. The additional row of stop logs raised the conservation pool elevation to its present-day level of 976.8 feet.

3-06. Principal Regulation Problems.

a. Reservoir Shoreline Erosion. High reservoir levels have created numerous erosion sites with cut banks ranging from 2 to 10 feet high. The St. Paul District received a number of complaints regarding shoreline erosion following high reservoir levels in 1986. The District surveyed and flagged the Federal flowage easement taking line at several of the erosion sites. The survey revealed that a majority of the erosion is occurring in areas that are well within the flowage easement.

b. Damage to Reservoir Shoreline Structures and Land. Lake Traverse is surrounded by hundreds of assorted structures ranging from farmstead outbuildings to resort cabins and seasonal and permanent homes. High lake levels in the spring and summer of 1986 caused approximately $500,000 in damage to some of these structures. Significant additional damages included lost resort business and evacuation of homes and cabins. A majority of the affected structures, though, are within the Federal intermittent flowage easement (below the taking line 983-foot contour elevation). A number of the structures are located within the permanent flowage easement (lake) basin (below the 977-foot contour elevation). Other damages associated with high reservoir levels include debris deposits at the high water line and the reintroduction of noxious weed seeds on the surrounding land. **Paragraph 2-05** contains additional information on the flowage easements.

c. Agricultural Damages. Agricultural damages occur both upstream and downstream of the project due to high reservoir levels and high outflows. A majority of the agricultural damages upstream of the project occur around Mud Lake, which has a much flatter shoreline than Lake Traverse. Approximately 2,000 acres adjacent to Mud Lake are within the elevation range of 975 to 981 feet. Most of this land is being used for pasture or cropland.

Agricultural flooding damages at Lake Traverse and Mud Lake include stranding of debris, introduction of weed seeds, damage to fences, wet soils which prevent planting or pasturage, and damage to crops. The Corps' flowage easement extends to elevation 983 feet.

Agricultural damages downstream of the dam occur when local inflows plus releases from the dam exceed channel capacity. These damages also include crop losses and the inability to use the land (e.g., pastureland).

d. Reservoir Shoreline Damage Due to Ice. Some residents adjacent to Lake Traverse have experienced damage from ice, particularly when water levels are above elevation 976.8 feet at freeze-up. High lake levels, combined with weather conducive to ice jacking mechanisms, can be highly destructive to structures located next to the lake.

The conservation pool elevation for Lake Traverse Reservoir is 976.0 feet. The reservoir is regulated to maintain elevation 976.0 under the water control plan (see **Paragraph 7-03**). Therefore, under normal operating conditions, the pool will be below elevation 977 feet at freeze-up.

e. Avian Botulism. Avian botulism is a paralytic disease of birds resulting from ingestion of toxin produced by the bacterium *Clostridium botulinum*. Toxin production occurs during the multiplication of the vegetative form of the bacteria. Optimum

growth of the bacteria occurs in sediments without oxygen, in the presence of decaying organic matter, at temperature of about 77 °F, in circumneutral pH. Environmental factors which contribute to botulism outbreaks in birds include the presence of large numbers of birds, warm temperatures, decaying vegetation and bird carcasses, and declining water levels that expose anoxic soils.

Outbreaks of avian botulism occurred in August 1992 and in August 1993 on Mud Lake. Over 2,600 and 7,300 ducks, geese, and other water birds died during outbreaks in 1992 and 1993, respectively. The outbreaks coincided with water level declines in Mud Lake. Control measures practiced by the U.S. Fish and Wildlife Service and State wildlife agencies, once a botulism outbreak occurs, include collection and disposal of dead birds. The potential for botulism outbreaks can be reduced by avoiding declining water levels during warm weather periods. Future management of Mud Lake will include the avoidance of declining water levels during summer and early fall, to limit exposure of anoxic soils to birds (see **Chapter VII and Exhibit** D).

f. Water Quality. Releases from the Lake Traverse Project contain high dissolved solids, sulfates, and dissolved organics. These cause hardness and taste and odor problems for the municipal water utilities at Fargo, North Dakota, and Moorhead, Minnesota, and impose increased water treatment costs. Releases that occur during cold water periods (fall and winter) create the greatest problem (see **Paragraphs 4-08, 7-07, and 8-04**).

IV - WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Lake Traverse Project forms the headwaters of the Bois de Sioux River. The Bois de Sioux River basin is roughly circular in shape and constitutes the southern limit (headwaters) of the Red River of the North watershed. The Bois de Sioux River flows northward to the Wahpeton, North Dakota-Breckenridge, Minnesota, area where it meets the Ottertail River to form the Red River of the North. The basin occupies portions of Minnesota, North Dakota, and South Dakota. The total drainage area of the watershed is 2,340 square miles, making it one of the largest subbasins in the Red River Valley. White Rock Dam controls 1,160 square miles of the total area. Elevations in the basin range from 950 to 1,200 feet. The river drops about 30 feet from Lake Traverse to Wahpeton, or about 0.3 foot per mile of river channel (**Plate 2-2**).

The Mustinka River is the largest tributary to the Lake Traverse Project. The basin has a drainage area equal to 869 square miles which is 75 percent of the total area above White Rock Dam. The river begins in the glacial moraine hills in the northeast portion of the basin and flows into Lake Traverse just upstream of Reservation Dam. The valley along the upstream portion of the river is well defined. However, the terrain becomes very level near Norcross, Minnesota, and drainage divides upstream of that point are not easily discernible (**Plate 2-2**).

The Rabbit River joins the Bois de Sioux River downstream of White Rock Dam. It flows into the channelized portion of the Bois de Sioux River and has a drainage area of approximately 330 square miles. The Rabbit River flows westerly, joining the Bois de Sioux River about 12 miles south of Breckenridge. The basin is quite flat but can produce high discharges over several days in response to intense summer rainstorms (**Plate 2-2**).

Most of the Bois de Sioux River basin has sparse vegetation with very few trees. The land area in much of the basin is plowed for row-crop agriculture. Numerous small lakes and wetlands on the perimeters of the basin and in the Upper Bois de Sioux River marshes provide excellent habitat for wildlife.

4-02. Topography. Generally, the topography of the Bois de Sioux River basin is subdued. A near-level glacial lake plain covers most of the eastern portion, and gently rolling glaciated uplands characterize the western portion. Between the rolling hills and the flat plain is a transition zone composed of a series of ridges with moderate slopes that are former beach ridges of glacial Lake Agassiz.

On the northwest and northeast perimeters of the basin, it is difficult to distinguish the drainage divides between the Bois de Sioux and the Wild Rice River watersheds (NW) and the Mustinka and Ottertail River watersheds (NE).

4-03. Geology and Soils. The area surrounding the Lake Traverse Project is covered by a mantle of glacial drift 100 to 300 feet deep. The drift is till or boulder-clay, imperfectly stratified within the area that was once the bed of the ancient glacial Lake Agassiz. The natural descent of the land is to the north. However, free drainage from the glacial melting was blocked by the ice sheet. As the sheet melted and retreated northward, it formed a lake in back of it, which filled the depression left by the continental glacier. At first, this water covered the nearly level, gently undulating surface of the drift to an elevation of about 1,100 feet above sea level. Over time, however, the ever increasing volume of water raised the lake level and produced an outlet to the south which gradually cut into the drift a trough 125 to 150 feet deep and 1 to 2 miles wide. As the outflow increased in volume, it produced a remarkable excavation that today is the Minnesota River valley. Through this valley, the ancient River Warren drained glacial Lake Agassiz. The present-day lakes of Big Stone and Traverse lie in the depression that was once the outlet of the ancient lake. Lake Winnipeg, Lake of the Woods, Lake Manitoba, Lake Winnipegosis, Lake Dauphin, Cedar Lake, and Moose Lake are large lakes which are remnants of glacial Lake Agassiz. The ancient lakebed, which is now the valley of the Red River of the North, ranges in width from 30 to 200 miles, and has a total length of at least 600 miles.

Before the southern outlet of glacial Lake Agassiz was formed, the lake level stood about 75 feet above the present surface of Lake Traverse or about 1,050 feet above sea level. At this point, a beach (Herman or Upper Beach) was formed around the perimeter of the lake; the location of Herman Beach was determined by survey in 1881 (along with three additional beaches). By the next epoch, however, the drift under the outlet had eroded to a depth of 75 feet over a distance of about 50 miles in the area where Big Stone Lake and Lake Traverse are now located. At this point, the lake level became stationary long enough to form another beach (Norcross Beach). A third beach (Campbell Beach) was formed when the outlet had been lowered another 50 feet to about 975 feet above sea level. A fourth beach (McCouleyville Beach) is the lowest beach which could be attributed to the erosion of the drift under the southern outlet of the lake. It was formed after further erosion lowered the outlet channel to about 960 feet above sea level. The separation of this outlet into two separate lakes (Big Stone and Traverse) was the result of a delta formed by the Little Minnesota River which entered the ancient outlet channel (River Warren) at a point now known as Browns Valley, Minnesota. The delta formed a divide which separated the two lakes except during extreme high stages (**Plate 2-1**).

4-04. Sediment. The Mustinka River and shoreline erosion are the primary sources of sediment into the reservoir. Secondary sources include the small streams and drainage ditches that enter the reservoir directly. Runoff from agricultural fields and streambank erosion provide a majority of the sediment load. The Bois de Sioux Watershed District has a goal of reducing sediment loading into Lake Traverse. The sediment load for Lake Traverse was derived from information gathered for nearby Big Stone Lake. It is estimated that less than 5 percent of Lake Traverse's volume has been filled by sediment since the project was built.

4-05. Climate. The climate in the region varies between cold winters and warm summers, which is typical of continental conditions in the temperate zone. The growing season, the time between killing frosts, averages about 113 days, with killing frosts recorded as late as June and as early as August. The climate is favorable for wheat, corn, soybeans, and other small grains. Historical temperature, precipitation, and evaporation values at typical National Weather Service stations in and adjacent to the Bois de Sioux River basin are shown in **Tables 4-1, 4-2, and 4-3**, respectively.

a. Temperature. The mean annual temperature in the area is about 43 degrees Fahrenheit (°F). Extremes ranging from -44° F to 114° F have been recorded. Normal monthly temperatures (30-year average) for the National Weather Service gages at Wheaton, Minnesota, and Fargo, North Dakota, are listed in **Table 4-1.** On the average, the first killing frost occurs on 22 September.

TABLE 4-1

Normal Temperatures at the National Weather Service Gages at Wheaton, Minnesota and Fargo, North Dakota In Degrees Fahrenheit

Month	Wheaton, MN	Fargo, ND Airport
January	10.6	6.3
February	16.8	11.8
March	28.7	25.2
April	45.4	42.8
May	58.6	55.6
June	68.0	65.0
July	73.2	71.0
August	71.3	69.0
September	61.4	57.8
October	49.6	46.2
November	31.9	28.0
December	16.6	12.3
Annual	44.3	40.9
Period of Record	1951-80 1988-90	1942-91

b. Precipitation. The mean annual precipitation over the entire basin is about 22.0 inches, with more than 76 percent of the precipitation falling during the months of April through October, inclusive. Precipitation in the winter generally occurs as snow and constitutes about 15 percent of the annual amount. Average monthly precipitation for the National Weather Service gages at Wheaton, Minnesota and Fargo, North Dakota are listed in **Table 4-2**.

TABLE 4-2

Average Precipitation at the National Weather Service Gages at Wheaton, Minnesota and Fargo, North Dakota In Inches

Month	Wheaton, MN	Fargo, ND Airport
January	0.66	0.33
February	0.55	0.33
March	1.22	0.80
April	2.08	1.88
May	2.70	2.37
June	3.85	3.80
July	2.99	2.92
August	2.55	2.83
September	1.92	1.93
October	1.53	1.32
November	0.91	0.76
December	0.56	0.50
Annual	21.41	19.77
Period of Record	1949-56 1958-86 1988-90	1949-90

c. Evaporation. Evaporation represents a major portion of the water lost from the reservoir during the period April through October. Evaporation from Lake Traverse has been estimated to average about 30 inches per open water season. Average monthly pan evaporation for the National Weather Service gage at Fargo, North Dakota, is listed in **Table 4-3.** Evaporation from lakes is less than pan evaporation, due to cooler water temperatures.

TABLE 4-3

Average Pan Evaporation for the National Weather Service Gage at Fargo, North Dakota In Inches

Month	Fargo, ND Airport
January	NA
February	NA
March	NA
April	3.64
May	7.15
June	7.41
July	8.43
August	7.31
September	4.95
October	3.29
November	NA
December	NA
Period of Record	1963-80 (Gage Discontinued)

d. Wind. The average wind speed in this area is about 10 miles per hour. The prevailing winds are from the northwest, but southeast winds are very common during the summer. Wind speeds are usually highest during the afternoon and lowest at night.

4-06. Storms and Floods. Flood information prior to 1897 in the vicinity of Lake Traverse is vague. Records of gage heights at Grand Forks, North Dakota, were initiated in April 1882 by the U.S. Army Corps of Engineers and taken over by the U.S. Geological Survey in May 1901 and kept continuously to date. This record is probably the only indication of probable flooding in the Lake Traverse-Bois de Sioux River basin during the period 1882 to the early 1900's. Records in Winnipeg indicate fairly reliable evidence of floods dating back to 1826, with indications that large floods occurred in 1826, 1852, and 1861.

A summary of major floods follows, including some that occurred prior to the construction of the project in 1941. A summary of the peak discharges and elevation/stages at White Rock Dam and Wahpeton, North Dakota, is shown in **Table 4-4**.

a. Spring 1897. The highest flood of record since 1882 occurred in 1897. Very heavy precipitation occurred during the summer of 1896, with the heaviest amounts falling in July. This was followed by above-normal snowfall, resulting in a heavy snow cover by March 1897. Just prior to the spring breakup, the average depth

of snow cover on the watershed was 26 inches. All of the snow melted in approximately 20 days. The Bois de Sioux River at Wahpeton crested at 17.00 feet (**Table 4-4**). Although this flood produced the highest discharge on record (10,500 cfs), the stage was exceeded by the 1989 flood (8,380 cfs, 17.84 feet) primarily due to ice effects.

b. April 1916. The flood of 1916 caused the level of Lake Traverse to rise to an elevation of 981.0 feet and is the flood used to design the project. The 1916 flood was the result of a heavy snowpack followed by rapid warming and runoff.

c. April 1952. The autumn of 1951 was characterized by cold, wet weather. November was much colder than normal, which resulted in the ground being frozen before the snow arrived. The winter of 1951-52 was characterized by above average precipitation and lower-than-average temperatures. On 20 March, the water equivalent of the snow in the basin ranged from 4 to 5 inches. A heavy snowfall occurred on 22-23 March, further increasing the runoff potential. Temperatures started to rise quickly on 28 March, and by 10 April, major flooding was occurring in the basin. On 12 April, the crest at Wahpeton (14.99 feet) was almost 5.0 feet above flood stage. The reservoir reached a peak elevation of 980.75 on 27 April (**Table 4-4**).

d. Spring 1969. Excessive precipitation occurred in the Red River Valley from October 1968 until February 1969. The precipitation ranged from 150 to 250 percent of the normal for the area. The water equivalent of the snow on 14 March ranged from 4 to 6 inches, with the highest amounts recorded in the southern portion of the basin. For the same period, temperatures in the region were 2 to 10 degrees Fahrenheit below normal. Frost depths in the basin ranged from 24 to 48 inches.

Inflow to Lake Traverse was heavy, but releases were delayed as long as possible to allow local inflow between the dam and Wahpeton to pass downstream. By 9 April, runoff in the basin had accelerated materially. At Wahpeton, the river rose 5 feet in 24 hours. On 10 April, the crest at Wahpeton (16.34 feet) was almost 6.5 feet above flood stage. The reservoir reached a peak elevation of 981.03 on 10 April (**Table 4-4**). If the Lake Traverse Project had not been built, the peak discharge at Wahpeton in 1969 (9,200 cfs) probably would have exceeded the 1897 peak (10,500 cfs).

e. Spring 1979. Precipitation in the Red River basin was slightly below normal in the fall of 1978. However, it was nearly 200 percent of normal for the months of November through April. By mid-March, the water equivalent of the snow in the headwaters (Lake Traverse) averaged 3 to 4 inches. Warm temperatures and rainfall during the next 4 weeks resulted in a large runoff. On 9 April, the Bois de Sioux River at Wahpeton crested at 15.44 feet or

approximately 5.5 feet above flood stage. The river rose at a rate equal to 1.37 feet per day. The reservoir reached a peak elevation of 979.41 feet on 14 April (**Table 4-4**).

f. Spring 1989. Snow began accumulating in the Red River basin in mid-November 1988. At the Fargo gage, precipitation for the months of November 1988 through March 1989 equaled 5.84 inches, which is 180 percent above normal. By 22 March, the water content of the snow in the basin varied from 1 to 5 inches, with the greatest concentration located south of Fargo on the Minnesota side. Rain fell from 29 March through 3 April. As a result, the Red River and Bois de Sioux River began to rise above flood stage at Wahpeton, eventually reaching the highest stage on record (17.84 feet, 8,300 cfs) on 5 April. Ice in the channel contributed to the high stage, raising the water level 1.7 feet above the open water condition. The river rose at a maximum rate of 1.59 feet per day. The reservoir reached a peak elevation of 977.98 feet on 4 April (**Table 4-4**).

g. Summer 1993. Two to 4 inches of rain fell over the basin in May. This was followed by a total of 3 to 5 inches in June. In July, some portions of the basin received up to 8 inches of rainfall. This resulted in a peak reservoir elevation of 980.0 feet on 31 July 1993 (**Table 4-4**).

Table 4-4

Summary of Peak Discharges and Elevations/Stages at White Rock Dam, Reservation Dam, and Wahpeton, ND For Selected Floods

White Rock Dam[1]		Lake Traverse		Wahpeton, ND Gage[2]		
Date	Peak Discharge cfs	Date	Peak Elevation Feet[3]	Date	Peak Discharge cfs	Peak Stage Feet[4]
---	---	---	---	1897	10,500[5]	17.00
---	---	4/1916	981.00	4/1916	---	14.80[7]
4/20/69	3,770	4/17/69	981.03	4/10/69	9,200	16.34
5/07/86	1,830	5/14/86	980.71	3/30/86	6,140	14.31
8/04/93	1,300	7/31/93	980.00	7/27/93	4,850[6]	12.55
4/14/89	600	4/02/89	977.98	4/04/89	8,300	17.84[8]
6/03/52	1,410	4/27/52	980.75	4/12/52	7,130	14.99
5/04/79	1,030	4/29/79	979.41	4/14/79	7,050	15.44

1. U.S.G.S. Gage No. 05050000, 300 ft. downstream of the dam. A small tributary enters the channel upstream of the gage.
2. U.S.G.S. Gage No. 05051500, Gage Datum = 942.97 ft., 1929 NGVD adj. The dam was constructed in 1941.
3. Corps Gage, 1912 NGVD Adjustment
4. Project Control Point, Flood Stage = 10 feet
5. Estimate by the U.S.G.S
6. Provisional
7. Corps Report on Survey of Red River of the N dated 24 September 1947
8. This stage was ice-affected.

4-07. Runoff Characteristics. A report published by the U.S. Department of Agriculture (Bulletin No. 1017) **(see Exhibit B, Item 13)** includes a comprehensive study of floods and flooding in the Red River Valley for the period 1893-1920. This study showed that snow has an important effect on runoff during March and April. Snow accumulates in varying quantities during parts of all of the months of November to March inclusive. The runoff resulting from

this stored precipitation was studied for the above period. It was found that when a considerable portion of the watershed was covered with snow to a depth exceeding 15 inches, and when, on or near 1 March, 12 inches or more of the winter accumulation of snow was still on the watershed, high stages would result in the principal streams. Historically, spring snowmelt combined with rainfall has caused all the major flooding in the Bois de Sioux River basin. The northward flow of the Bois de Sioux/Red River is unique and an important element in influencing the magnitude of these snowmelt floods. When temperatures in the southern half of the basin rise faster than in the northern part, the flow of water to the north is impeded. Ice accumulations in stream channels, particularly at bridges and restricted reaches, can increase upstream river levels. Large rainstorms can also cause flooding in the Bois de Sioux River basin, although it is unusual due to its relatively large drainage area.

The percent of time a given annual inflow or outflow, to or from the Lake Traverse Project, is equaled or exceeded (annual flow duration) is shown on **Plates 4-1 and 4-2**. The mean monthly and annual inflow and outflow distributions for the project are presented on **Plates 4-3 and 4-4**. **Plate 4-5** illustrates the variation in monthly streamflow at the Wahpeton, North Dakota, control point. Monthly inflow and outflow duration is shown in **Tables 4-5 and 4-6**. Average monthly and annual reservoir inflows and outflows are listed in **Tables 4-7 and 4-8**. Daily inflows were

developed by storage calculations using lake elevations and outflows from 1942 through 1993.

Maximum monthly outflow occurs in May and June. The maximum monthly inflow occurs in April, May, and June from snowmelt and spring rain runoff, but most of the spring inflow is retained in the reservoir for flood protection purposes. As a result of this retention, monthly inflows generally exceed outflows during the spring as the reservoir is filling. In the summer, the highest evaporation losses occur, and outflows are reduced. Outflows are increased in late winter as necessary to draw the reservoir down to provide flood storage capacity (see **Paragraph 7-05**).

TABLE 4-5
LAKE TRAVERSE PROJECT
RESERVOIR INFLOW-DURATION TABLE
YEARS 1942 THROUGH 1993

FLOW CFS	PERCENT OF TIME AT OR ABOVE INDICATED ELEVATION												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL SEASON
14000													
13500						0.11							
13000						0.11							
12500						0.11							
12000						0.11							
11500						0.11							
11000						0.11							
10500						0.11							
10000				0.28		0.11							
9500				0.28		0.11							
9000				0.37		0.11							
8500				0.47		0.11							
8000				0.47		0.11							
7500				0.56		0.11							
7000				0.75		0.11							0.10
6500			0.26	0.84		0.11							0.13
6000			0.35	0.93	0.11	0.11							0.17
5500			0.43	1.21	0.11	0.11	0.27						0.23
5000			0.61	1.40	0.22	0.11	0.41						0.29
4500			1.13	2.24	0.55	0.23	0.55						0.50
4000			1.30	2.99	0.77	0.46	0.82						0.66
3500			1.48	3.45	1.10	1.14	1.50				0.50		0.92
3000			2.26	5.51	1.64	1.60	1.91	0.15		0.14	0.76		1.41
2500		0.15	2.95	7.38	2.74	2.85	2.46	0.15		0.54	0.88		2.01
2000		0.15	4.25	11.76	3.94	5.37	3.69	0.15	0.59	1.22	1.13		3.20
1500		0.30	6.94	17.93	7.12	8.68	6.83	0.60	1.33	2.16	1.39		5.23
1000		0.30	10.76	28.29	14.13	15.30	12.98	3.28	4.27	5.27	3.40	0.27	9.39
500	0.65	1.06	19.44	50.23	36.47	37.90	29.10	16.27	17.38	20.68	11.08	1.21	22.06
0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4-6
LAKE TRAVERSE PROJECT
RESERVOIR TAILWATER OUTFLOW-DURATION TABLE
YEARS 1942 THROUGH 1993

FLOW CFS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ALL SEASON
				PERCENT OF TIME AT OR ABOVE INDICATED ELEVATION									
3500													
3400				0.16									
3300				0.99									
3200				0.99									
3100				0.99									
3000				0.99									
2900				0.99									
2800				1.15									0.11
2700				1.15									0.11
2600				1.15									0.11
2500				1.15									0.11
2400				1.48									0.15
2300				1.48									0.15
2200				1.48									0.15
2100				1.48									0.15
2000				1.64									0.16
1900				1.64									0.16
1800				1.64			0.11						0.18
1700				1.64		0.64	0.11						0.28
1600				1.64	0.66	0.64	0.11						0.38
1500				2.30	0.77	0.74	0.11	1.28					0.62
1400				2.30	0.77	1.38	0.11	1.43					0.74
1300				2.30	0.77	2.65	0.22	2.00					1.02
1200				3.95	3.07	6.67	0.22	2.71					2.23
1100				4.77	6.48	9.43	2.83	6.85	5.39	2.53			4.81
1000				7.07	11.75	13.14	4.35	8.42	5.39	2.53			6.81
900			2.76	18.42	21.62	15.47	10.43	8.70	5.39	3.16			10.87
800			2.76	21.38	26.45	16.31	13.26	8.84	5.39	3.16			12.46
700			2.76	26.32	29.53	21.08	16.41	9.13	5.39	3.16			14.66
600			4.42	34.70	34.36	28.92	20.76	9.27	5.39	4.63			18.28
500			5.52	37.99	36.22	32.31	23.59	9.27	5.39	4.84	2.94		20.03
400			9.39	43.75	40.72	40.04	26.20	9.27	5.57	8.84	2.94		23.32
300			19.89	52.47	48.30	45.44	32.83	11.41	9.69	10.11	2.94		28.19
200			21.55	60.69	50.82	50.42	38.48	17.40	12.21	12.63	6.86		32.38
100			35.36	72.37	68.06	61.76	46.20	32.81	18.67	19.79	13.07	4.02	42.84
0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4-7
SUMMARY OF AVERAGE MONTHLY / ANNUAL RESERVOIR INFLOW
YEARS 1942 THROUGH 1993

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL INFLOW
	MEAN MONTHLY / ANNUAL INFLOW IN CFS												
1942	3	1	107	542	1059	1040	337	295	652	357	174	93	389
1943	51	32	475	1943	487	742	538	125	189	176	62	14	402
1944	43	22	62	611	1173	1161	490	189	177	171	172	2	357
1945	15	46	558	773	465	388	176	149	242	141	34	18	251
1946	20	141	662	491	593	444	398	196	251	383	134	9	311
1947	23	5	140	1431	457	465	245	346	116	299	70	10	301
1948	11	20	1036	991	462	523	250	163	363	306	814	14	413
1949	17	0	218	520	474	360	573	266	306	508	162	14	287
1950	10	18	563	749	902	565	636	436	287	514	142	42	408
1951	77	38	165	1366	540	358	329	194	128	285	62	48	299
1952	51	21	103	2630	396	482	359	440	395	230	217	82	449
1953	22	45	328	311	639	477	96	239	212	245	428	25	256
1954	4	75	101	155	242	633	177	123	171	255	381	1	193
1955	1	19	118	920	225	323	280	88	341	170	134	31	220
1956	96	167	322	370	284	152	187	255	72	300	144	7	197
1957	0	46	212	516	398	508	213	169	231	131	343	68	236
1958	35	118	100	426	280	149	194	75	382	247	339	20	196
1959	0	1306	316	219	583	443	296	112	171	168	95	161	315
1960	80	89	126	714	251	239	127	97	153	256	191	31	196
1961	15	42	152	222	199	108	89	121	350	300	221	25	154
1962	3	0	1124	1159	1752	691	1023	299	173	121	195	76	556
1963	27	1	138	863	460	1235	300	137	231	85	244	39	312
1964	23	35	79	532	673	403	130	159	295	192	89	36	221
1965	54	54	54	1078	1026	1595	584	196	179	539	156	65	465
1966	50	117	1246	541	385	279	179	455	110	623	44	76	345
1967	44	32	602	877	649	385	285	84	111	382	55	30	296
1968	37	0	221	499	334	277	389	311	230	270	61	66	226
1969	61	33	77	3105	516	660	154	229	311	298	135	40	465
1970	15	127	182	668	552	413	191	111	460	246	137	21	260
1971	0	61	387	394	252	496	57	135	138	303	204	22	204
1972	24	75	777	502	969	594	355	404	535	310	230	61	405
1973	20	49	287	826	595	520	299	401	295	547	157	53	339
1974	26	30	80	256	424	347	204	567	481	570	225	63	274
1975	292	26	90	732	566	569	642	661	216	551	728	17	426
1976	55	160	371	943	696	584	606	379	460	370	73	15	393
1977	78	33	258	462	251	511	360	11	13	13	13	13	168
1978	13	13	1095	1566	334	803	760	355	432	290	207	42	494
1979	18	20	173	1707	486	795	633	386	343	232	208	28	419
1980	66	14	131	282	313	649	388	414	364	526	275	100	295
1981	38	148	44	664	646	339	287	143	211	257	198	60	253
1982	79	31	226	831	391	296	354	213	371	350	191	65	284
1983	42	25	199	431	575	223	234	338	291	286	257	79	250
1984	66	153	858	1128	464	1289	1064	274	206	579	531	277	575
1985	50	220	1628	809	378	957	231	278	338	438	140	40	460
1986	68	51	1471	1864	875	811	426	377	663	202	328	75	602
1987	98	76	422	472	483	290	239	227	339	330	200	45	269
1988	125	108	93	302	511	149	177	299	150	510	219	10	222
1989	19	5	709	1395	429	510	275	116	461	260	268	34	373
1990	111	65	141	574	325	278	126	223	279	304	254	32	226
1991	20	135	161	355	392	563	891	194	241	275	77	34	279
1992	40	39	179	497	365	317	262	234	308	171	144	43	217
1993	39	21	731	815	369	638	2396	667	359	566	169	68	575
PERIOD MEAN (1942-1993)	44	81	387	827	530	539	394	257	284	316	206	47	326

PERIOD (1942-1993) MONTHLY MAXIMUMS AND MINIMUMS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MINIMUM	1	1	4	1	2	3	1	1	5	2	1	1
YEAR	1963	1963	1944	1982	1979	1958	1975	1948	1961	1944	1952	1965
MAXIMUM	999	2612	9298	13342	6223	13938	5828	3181	2453	3251	3986	1331
YEAR	1975	1959	1978	1969	1965	1965	1993	1975	1942	1973	1975	1984

TABLE 4-8
SUMMARY OF AVERAGE MONTHLY / ANNUAL RESERVOIR OUTFLOW
YEARS 1942 THROUGH 1993

YEAR	MEAN MONTHLY / ANNUAL OUTFLOW IN CFS												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL OUTFLOW
1942	0	0	0	0	11	134	708	221	267	43	0	0	116
1943	0	0	0	318	900	785	389	37	10	10	0	0	205
1944	0	0	1	201	380	862	310	18	10	5	0	0	149
1945	0	0	0	408	31	197	10	10	10	10	2	0	56
1946	0	0	0	587	23	10	37	10	10	10	2	0	57
1947	0	0	2	257	580	383	2	0	0	0	8	20	105
1948	7	0	0	327	790	71	3	0	0	0	0	0	101
1949	0	0	0	0	0	0	33	10	10	10	7	0	6
1950	0	0	0	0	0	483	740	469	28	10	2	0	146
1951	0	0	0	195	995	390	102	28	10	10	4	0	146
1952	0	0	0	0	1018	1192	329	6	0	0	0	0	213
1953	0	0	0	0	0	20	30	30	30	4	0	0	10
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	27	190	190	36	9	16	32	35	7	45
1958	7	5	31	197	43	3	2	0	0	0	0	0	24
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	75	74	24	0	0	0	0	0	14
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	57	319	594	784	1037	207	36	5	2	256
1963	1	1	10	15	8	486	86	7	4	11	28	0	54
1964	0	0	0	62	75	17	3	0	0	0	0	0	13
1965	0	0	0	235	415	1243	299	14	4	55	83	45	199
1966	17	40	28	305	844	425	7	0	0	21	0	0	141
1967	0	0	0	204	118	32	220	0	0	0	0	0	48
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	1238	1340	332	22	0	0	0	0	0	245
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	98	12	0	0	0	0	0	9
1972	0	0	58	595	211	375	26	132	27	0	0	0	118
1973	0	0	120	94	8	5	0	0	0	0	0	0	19
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	8	172	103	307	48	64	3	0	0	59
1976	0	5	199	144	0	0	0	0	0	0	0	0	29
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	586	689	541	417	125	21	0	0	0	199
1979	0	0	0	122	888	691	301	98	12	8	0	0	178
1980	0	0	0	15	20	39	19	4	0	0	0	0	8
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	840	252	513	378	66	0	102	266	50	205
1985	0	0	194	331	131	287	55	10	37	0	0	0	87
1986	0	0	0	590	844	980	777	137	104	390	59	32	328
1987	23	24	6	36	16	1	0	0	0	8	8	3	10
1988	0	0	3	41	3	0	0	0	0	0	0	0	4
1989	0	0	0	360	527	93	5	1	57	8	17	14	90
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	70	647	81	61	87	0	0	80
1992	0	0	0	0	0	0	17	105	0	0	0	0	10
1993	0	0	107	594	281	246	697	1084	1100	653	12	0	400
PERIOD MEAN (1942-1993)	1	1	15	173	235	230	151	73	40	29	10	3	80

	PERIOD (1942-1993) MONTHLY MAXIMUMS AND MINIMUMS											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MINIMUM	1	1	7	15	1	10	1	5	3	5	1	1
YEAR	1963	1963	1963	1963	1987	1945	1958	1957	1963	1962	1962	1962
MAXIMUM	30	54	900	3450	1620	1710	1800	1520	1100	1100	540	100
YEAR	1966	1966	1985	1969	1969	1944	1943	1962	1993	1993	1984	1984

4-08. Water Quality. Lake Traverse is a shallow wind-swept lake located in one of the uppermost reaches of the Red River of the North watershed. Geomorphic characteristics, long hydraulic retention times, and high annual evaporation rates have resulted in a lake with an extremely high mineral content (dissolved solids, especially sulfate). Its mineral characteristics render the water almost useless as a source of municipal and industrial supply because softening is too expensive and often ineffectual. In addition, nutrient-laden runoff into Lake Traverse and Mud Lake from their mostly agricultural watersheds promotes the excessive growth of blue-green algae and high levels of dissolved organics. The algae, or substances produced by the algae, and vegetation in Mud Lake, are thought to cause taste and odor problems, and also may contribute to the production of trihalomethanes in chlorinated water supplies (see **Paragraphs 3-06.f., 7-07, and 8-04**).

4-09. Channel and Floodway Characteristics. The Bois de Sioux River channel extends downstream of White Rock Dam for approximately 24 miles. The channel bottom is 60 feet wide with side slopes of 1 on 3. The longitudinal slope from White Rock Dam to the mouth of the Rabbit River is about 0.5 foot per mile. This section is designed to carry 1,100 cubic feet per second with freeboard equal to 1 foot. The Rabbit River is the major tributary to the channel, with a drainage area of approximately 330 square miles. From the Rabbit River to the end of the project, the longitudinal slope is about 0.06 foot per mile with a capacity of

2,000 cubic feet per second. Agricultural damages can occur all along the Bois de Sioux River when it exceeds channel capacity. The channel is lined with spoil banks on both sides. Local landowners, however, have cut through the banks in many places in order to facilitate local drainage. The only control point downstream of the dam is at Wahpeton-Breckenridge. The reservoir is regulated for this urban damage center when the stage at Wahpeton exceeds 10 or 12 feet (**see Chapter VII**). The travel time between the dam and Wahpeton varies between 24 and 48 hours, depending on the amount of flow. A dye study done in April 1993, when the project was discharging 600 cfs, indicated a travel time of 32 hours. A general plan and a typical cross section of the channel are shown on **Plate 2-9**. An elevation-discharge curve for U.S.G.S. gage No. 05050000, just below White Rock Dam, is shown on **Plate 4-6**. A family of discharge-rating curves for the low-flow gate at White Rock Dam is shown on **Plate 4-7**. The discharge from the low-flow gate can also be determined from **Plate 4-8** which was used to develop **Plate 4-7**. An elevation-discharge curve for U.S.G.S. gage No. 05051500 at Wahpeton, North Dakota, is shown on **Plate 4-9**.

4-10. Upstream Structures. There are no structures upstream of the Lake Traverse Project.

4-11. Downstream Structures. There are no structures directly downstream of the Lake Traverse Project. The Bois de Sioux River, however, joins the Otter Tail River at Wahpeton, North Dakota-Breckenridge, Minnesota, to form the Red River of the North. Orwell Dam, on the Otter Tail River, is also owned by the Corps of Engineers and controls a drainage area equal to 1,830 square miles. The travel time from Orwell Dam to Wahpeton averages about 1.5 days.

4-12. Economic Data.

a. Population. As of the 1990 census, Wahpeton, North Dakota, had a population of 8,751 while the surrounding county (Richland) had 18,148 residents. Forty-six percent of Wahpeton residents are under the age of 25. Thirty-eight percent are between 25 and 59, and 16 percent are 60 or older. The same census showed that Breckenridge, Minnesota, had 3,708 citizens while the county (Wilkin) had 7,516. Thirty-five percent of Breckenridge residents are under the age of 25. Forty-one percent are between 25 and 59, and 24 percent are 60 or older. Both of these cities lie about 30 miles downstream (north) of the Lake Traverse Project (**Plate 2-2**).

b. Agriculture. Of the total land in the Red River of the North Valley, 82.4 percent is used as cropland. The types of crops grown include wheat and other small grains, sugar beets, sunflowers, corn, and potatoes. Pasture and rangeland account for the next largest land use at 5.4 percent.

c. Industry. The major industries in the region are found in Wahpeton, North Dakota, and Breckenridge, Minnesota. The chief industries in Wahpeton include retail trade, educational services, manufacturing of nondurable/durable goods and construction. The labor force in Wahpeton numbered 4,428 in 1980, with an unemployment rate of 6.7 percent. Important industries in Breckenridge include the aforementioned at Wahpeton in addition to health services and transportation. The labor force in Breckenridge numbered 1,833 in 1980, with an unemployment rate of 3.5 percent. Agriculture is also a major industry for the two cities and the surrounding area.

d. Flood Damages. The primary authorized purpose for the Lake Traverse Project is flood damage reduction for the agricultural and urban damage centers along the Bois de Sioux and Red Rivers. Flood damages also occur within the reservoir during high stages, due to encroachment on Government flood easements by cottages and resorts near the reservoir.

The major agricultural reaches affected by the project include lands along the Bois de Sioux River from White Rock Dam to the end of the Bois de Sioux River channel, which ends 5 miles south of Wahpeton. Relationships for discharge-acres flooded and discharge-damage, along the Bois de Sioux River, are shown on **Plates 4-10 and 4-11.**

The major urban damage centers affected by the project include the cities of Wahpeton, North Dakota, and Breckenridge, Minnesota. The urban areas of Fargo, North Dakota, and Moorhead, Minnesota, are also affected by the project, but to a lesser extent than the Wahpeton-Breckenridge area. The National Weather Service flood stage at Wahpeton and Breckenridge is 10 feet as measured by the U.S.G.S. gage number 05051500, on the Red River of the North at Wahpeton, North Dakota. At a stage of 9.5 feet, sewers begin to flood in Wahpeton and emergency pumping is necessary. Damage at Breckenridge starts at a stage of about 10 feet. As river stages increase in Breckenridge, floodwater seeps from storm sewers into nearby sanitary sewers. Both cities have constructed levees which prevent most residential flooding up to the 15-foot stage in Wahpeton and about the 16-foot stage in Breckenridge. Discharge-damage curves for Wahpeton, Breckenridge, Fargo and Moorhead are shown on **Plates 4-12** through **4-15.**

High reservoir stages, wave action, and ice movement can cause damage to reservoir shoreline, permanent residences, summer homes, resorts, roads, bridges, and farmlands around the Lake Traverse Project. Because high-water damages occur most frequently during the 1 June to 30 September peak resort period, many commercial establishments experience a decline in net income.

Low-water damages around the project can also occur during the May through September recreation season. Low water causes a decline in net income to commercial activities (e.g., resorts). Low-water consequences include expenditures for dock extensions, reduced or canceled reservations because of access problems to fishing areas, and shortened resort stays because of poor fishing. Private landowners also experience increased expenses due to low water.

V - DATA COLLECTION AND COMMUNICATION NETWORK

5-01. Hydrometeorological Stations.

a. Facilities. The regulation and proper operation of the project require the collection and evaluation of several meteorological, hydraulic and hydrologic parameters. Pool and tailwater elevations, outflow, precipitation, wind, and air temperature are recorded at the project site. Data Collection Platforms (DCPs) are used for recording the pool and tailwater elevations at both Reservation and White Rock Dams. Equipment is also available for measuring the water content of snow, frost depth, and the lake ice thickness. Additional information is available at various Corps, U.S. Geological Survey (U.S.G.S.), and National Weather Service gages in the project area. **Table 5-1** lists the Corps' data collection facilities at the Lake Traverse Project. **Table 5-2** lists various streamflow gage sites in the area. **Plate 5-1** shows the locations of climate, river, and lake gages in the project area. **Plate 5-2** shows the locations of snow survey stations in the project area; **Table 5-3** lists these locations.

The Bois de Sioux River Watershed District (Wheaton, MN) maintains a gaging network within the basin which utilizes volunteer observers. Streamflow and stage information is available from the Watershed District. Locations for the gaging sites are on file in the Water Control Section.

Table 5-1

Lake Traverse Project Hydrometeorological Stations

Location	Data Type	Equipment	Notes
White Rock Dam	Pool Elevation	DCP[1] and a Recording Chart	Corps Gage
White Rock Dam	Tailwater Elevation	DCP[1] and a Recording Chart	U.S.G.S. Gage
White Rock Dam	Precipitation	Recording Gage	NWS Gage
White Rock Dam	Air Temperature	Thermometer	Corps Gage
White Rock Dam	Windspeed/Dir.	Anemometer	Corps Gage
White Rock Dam	Snow Depth/Water Content	Snow Tube	Corps Gage
White Rock Dam	Frost Depth	Frost Tube	Corps Gage
Reservation Dam	Pool Elevation	DCP[1], Recording Chart, Telemark	U.S.G.S. Gage
Reservation Dam	Tailwater Elev.	DCP[1] and a Recording Chart	Corps Gage
Reservation Dam	Ice Depth	Manual	Corps

1. There is one Data Collection Platform (DCP) at each dam, servicing both the pool and tailwater gages.

Table 5-2

Streamflow Stations in the Bois de Sioux River Basin

Gage No./Owner	Drainage Area Sq. Mi.	River and Location	Notes
U.S.G.S. 05050000	1,160	Bois de Sioux R. Nr White Rock, SD	300 feet downstream of White Rock Dam
Corps Staff Gage, ND U.S.G.S. Wire Weight Gage	1,540	MN Hwy 55 Bridge Nr Fairmount, ND	4 miles upstream of the Rabbit River
U.S.G.S. 05051300	1,880	Bois de Sioux R. Nr Doran, MN	3 Miles downstream From the Rabbit River
U.S.G.S. 05051500	4,010	Red R. of the N at Wahpeton, ND	Control Point for Lake Traverse Project
U.S.G.S. 05049000	834	Mustinka R. Above Wheaton, MN	75 Percent of Drainage Area to the Project
U.S.G.S. 05049200	68.5	Eighteen Mile Cr Nr Wheaton, MN	2 Miles Southwest of Wheaton, Minnesota
U.S.G.S. 05050700	56.1	Rabbit River Nr Nashua, MN	2.6 miles North of Nashua, Minnesota
Corps Wire Weight Gage	-----	Rabbit R. at Co. Rd 9, Nr Mouth	Can be affected by backwater

Table 5-3
Snow Survey Sites Within the Lake Traverse Project Area

Number and Name	Location
1. Wheaton	West of Wheaton on County Road No. 9
2. Dumont	East of Dumont
3. Graceville	2 mi. East of Graceville and 0.25 mile South
4. Chokio	3 miles North of Chokio on Co. Road No. 13
5. Herman	0.5 mi. NW of Herman on Hwy 9 and 1 mi. West
6. Elbow Lake	S of Elbow L. 1 mi. W of Hwy 54 on Co Rd No 1
7. Nashua	0.5 mi. East of Nashua on Hwy No. 55
8. Doran	1.0 mi. S of Doran on Hwy No. 9
9. Tenny	0.5 mi. South of Tenny
10. White Rock Dam	Lake Traverse Project Office

b. Reporting. The information needed to operate the dam and regulate the reservoir is provided to Water Control by the Project Resource Manager. Daily (0800) readings for the pool, tailwater, and outflow are given, as well as precipitation and wind readings. The pool and tailwater elevations are also recorded by DCPs and transmitted via satellite directly to Water Control's digital ground readout station (DGRS). At each DCP gage, the correspondence between the gage and DCP readings is checked visually by project personnel at regular intervals. Daily inflow to the reservoir is calculated by Water Control from the change inreservoir elevation and the outflow. In the winter and spring, snow depth, water content, frost depth, and lake ice thickness are reported weekly to Water Control. The snow survey is used to estimate the amount of water available for spring runoff. Frost depth readings provide information on the amount of infiltration expected. The snow and frost information is also provided to the National Weather Service and the State of Minnesota Climatology Office.

Daily data are reported to Water Control via telephone. Copies of the official site log sheets are mailed monthly to Water Control. Also, the daily meteorological record is compiled on National Weather Service Form E-15 and mailed monthly to the National Weather Service Forecast Office in Minneapolis, Minnesota.

c. Maintenance. The tailwater gage at White Rock Dam and the pool elevation gage at Reservation Dam are maintained by the U.S. Geological Survey. The National Weather Service maintains the precipitation gage. The rest of the gages listed in **Table 5-1** are maintained by the Water Control gage party.

5-02. Water Quality Stations.

a. Facilities. The Corps regularly maintains seven water quality data-collection stations on Lake Traverse, Mud Lake, and the Mustinka River. Station locations are shown on **Plate 5-3.** On-site vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance are monitored electronically at each station. In addition, vertically composited samples are taken from the top 2 meters of the Lake Traverse water column. A number of water quality measurements are made to track limnological conditions within Lake Traverse and quality of releases from the project. Sampling is accomplished by project personnel and local volunteers from the Bois de Sioux Watershed District. Fluorometers are occasionally used for special studies on the reservoir's adjacent streams.

The data is used to define baseline water quality conditions. This helps identify water quality trends, support locally sponsored lake management programs, and analyze water quality problems and concerns as they relate to natural conditions and water control operations.

b. Reporting. On-site water quality data is recorded on data sheets and mailed to the Water Quality Unit in the District office. Raw water samples analyzed for nutrients and chlorophyll are processed at the field site and shipped to a Corps-approved laboratory for analysis. All chemical analyses follow recommended Environmental Protection Agency (EPA) or equivalent procedures. Lab results are then forwarded to the Water Quality Unit. The data is reviewed and entered into DBASE and the USEPA's STORET data storage system. Project Water Quality Reports are generated on a yearly basis for the project site. The information is used to assess current trophic conditions in the reservoir and to evaluate the effects of operational changes and watershed management options on reservoir water quality and quality of releases from the project.

c. Maintenance. Maintenance of water quality equipment is under the direction of the Water Quality Unit in the St. Paul District Office.

5-03. Sediment Stations. The Corps of Engineers does not monitor sediment at the Lake Traverse Project.

5-04. Recording Hydrologic Data. Currently, the hydrometeorologic records collected are read into data base files on the computer system at the Water Control Section. The data from U.S.G.S. gages in the area are archived in the U.S.G.S. WATSTORE data base in Reston, Virginia. The daily precipitation data collected at White Rock Dam are archived by the National Climatic Data Center in Asheville, North Carolina.

5-05. Communication Network. The staff transmits hydrologic data by telephone the United States mail. Streamflow, water level, rainfall and other pertinent data are received regularly from the project during normal regulation periods and daily during periods of flooding (see **Paragraph 5-07**).

5-06. Communication with Project.

a. Regulating Office With Project Office. Water Control communicates with the project via the telephone. Present radio facilities do not allow for a reliable audible signal between St. Paul and the Lake Traverse Project. See the standing instructions to the Project Resource Manager in **Exhibit D.**

b. Between Project Office and Others. Local residents are well-attuned to fluctuations in the lake level, and they have access to lake level information from the Resource Manager, either by telephone, in person, or through the local news media. Flash flooding is not a problem in this area. Notifications of severe weather or impending unusual conditions would be handled through local law enforcement and civil defense authorities (see **Paragraph 5-08**).

5-07. Project Reporting Instructions. The Project Resource Manager will report hydrologic and climatic conditions to Water Control. Normally, these reports will be made each Monday, Wednesday and Friday. Water Control may request more frequent reports, if warranted by flooding situations, or less frequent reports under relatively quiescent conditions. Also, when the local 24-hour rainfall total exceeds 1.5 inches, the Resource Manager will notify Water Control as soon as possible.

5-08. Warnings. In the event of impending emergency conditions, or advisories requiring interim gate changes, Water Control will call the Resource Manager at the Lake Traverse Project. **Paragraph 1-05** contains phone numbers for project personnel. **Page vi** contains phone numbers for Water Control and various District personnel. In the event of other emergencies affecting project regulation and concerns downstream, the officials listed in **Table 5-4** will be contacted.

Table 5-4

Contacts for Emergency Notification

Point of Contact	Telephone Numbers	
	Work	Home
Traverse County, Minnesota Civil Defense Coordinator County Sheriff	612.563.4848 612.563.4244	612.563.8363 -------
Wilkin County, Minnesota Civil Defense Director County Sheriff (24 Hour)	218.643.4234 218.643.8544	218.643.5467 -------
Roberts County, South Dakota Civil Defense Coordinator County Sheriff (24 Hour)	605.698.3800 605.698.7667	605.698.4214 -------
Richland County, N. Dakota Civil Defense Coordinator County Sheriff	701.642.7788 701.642.7711	701.642.9363 -------
White Rock, South Dakota Call Roberts County Sheriff	605.698.7667	-------
Wahpeton, ND, Disaster Emergency Services Coord.	701.642.7788	701.642.9363
Breckenridge, MN Disaster Emergency Services Coord.	218.643.5506 24 Hour	-------
Minnesota Div. Emergency Man. Minnesota Statewide Emergency	612.296.2233 1.800.422.0798	------- -------
SD Emergency Management	605.773.3231	--------
ND Disaster Emerg. Management	701.224.2111	
Moorhead Water Utility Cliff McLain	218.299.5470	
Fargo Water Utility Ron Hendrickson	701.241.1469	--------

Note: Phone numbers for Water Control, District, and Project personnel are listed on **Pages vi and 1-5**.

VI - HYDROLOGIC FORECASTS

6-01. General. All river-stage forecasting in the public interest is done by the National Weather Service Forecast Office, in Minneapolis, Minnesota. The St. Paul District, Corps of Engineers, provides advisory forecasts as needed for its projects. Corps forecasts may arise from either wet or dry conditions, and are used to guide Water Control regulators and the Project Resource Manager in their tasks.

The water quality division of the State of Minnesota, Pollution Control Agency, forecasts water quality conditions when warranted. The St. Paul District may provide data through its water quality unit in the Environmental Resources Section.

6-02. Flood Condition Forecasts. All river-stage forecasting in the public interest is performed by the National Weather Service Forecast Office, in Minneapolis, Minnesota.

6-03. Conservation Purpose Forecasts. Forecasts for water conservation purposes are not required for the Lake Traverse Project.

6-04. Long Range Forecasts. Long-range forecasts of reservoir inflows and levels are not required for the Lake Traverse Project.

6-05. Drought Forecast. The South Dakota, North Dakota, and Minnesota Departments of Natural Resources and the National Weather Service routinely monitor and report drought indicators. Consult the Drought Contingency Plan for the project for additional information (see **Paragraph 1-03**).

VII - WATER CONTROL PLAN

7-01. General Objectives. The water control plan attempts to incorporate water control operations that optimize flood control performance, water conservation, recreation, and environmental conditions. It includes provisions for drawing down Lake Traverse to create storage for spring flood control. Conservation pool levels are maintained on both Lake Traverse and Mud Lake in the summer to facilitate recreation, and for fish and wildlife requirements.

7-02. Constraints. There are some notable physical constraints on water control operations for the Lake Traverse Project:

a. Bois de Sioux River Channel Capacity. Excessive vegetation growing in the bottom of the channelized portion of the Bois de Sioux River is a recurring problem during drought periods. During long periods without releases from White Rock Dam, vegetation in the channel bottom becomes much more dense. Also, other types of vegetation become established, such as cattails and willow brush, which offer considerably more resistance to flow. Dense vegetation can reduce design channel capacity (1,100 cfs) by as much as 50 percent, causing more frequent overbank flooding of adjoining agricultural land. The reduced channel capacity hampers

efforts to draw down Lake Traverse/Mud Lake from high pool levels, and reduces the effectiveness of the flood protection afforded by the project (see **Paragraph 8-13.b.**) Vegetation in the bottom of the channel will be monitored, and if necessary, mechanical vegetation control measures will be applied to maintain channel capacity.

b. Gate Icing. The stop logs, gates, and bulkheads at Reservation Dam and White Rock Dam are normally "frozen in" during the winter. They must be deiced before gate settings can be changed or stop logs removed. There are no built-in deicing mechanisms, so this work must be done by hand. Any plans for winter releases must take these factors into consideration.

c. Reservation Dam Low-Head Structure. The Reservation Dam outlet structure is a low-head, grouted riprap weir. The maximum head at the top of the stop logs (elevation 976.8 feet) is 2.8 feet at normal pool. The low-head nature of the structure results in long drawdown times. To lower the pool from elevation 976.8 feet to 974.5 feet (2.3 feet) takes about 3.5 weeks. To reduce the level an additional one-half foot to the sill elevation (974.0 feet) would require approximately one month.

d. Reservation Dam Low-Flow Conduits. The gates on the Reservation Dam low-flow conduits were damaged by ice. The conduits have been plugged and are no longer operable (see **Paragraph 2-03.d and Exhibit A**).

e. Avian Botulism. Outbreaks of avian botulism coincide with water level declines in Mud Lake. Mud Lake will be regulated to avoid declining water levels during the summer and fall, insofar as possible, to limit exposure of anoxic soils to birds (see **Paragraph 3-06.e.**)

7-03. Overall Plan for Water Control.

a. Lake Traverse Reservoir. Lake Traverse Reservoir (above Reservation Dam) is regulated between a minimum elevation of 974.0 feet (sill elevation) and elevation 981.0 feet (top of flood control pool). When Lake Traverse rises near elevation 976.8, all the stop logs are removed from Reservation Dam. Once the Lake Traverse and Mud Lake pools both reach approximately elevation 976.8 feet, control for Lake Traverse Reservoir shifts to White Rock Dam (see **Paragraph 2-03.a.**). The reservoir maximum design pool is at elevation 982.0 feet for both Lake Traverse and Mud Lake.

If the late February basin-average snow water content is less than 3.0 inches (Category I drawdown, normal spring runoff). Lake Traverse Reservoir is lowered to the target elevation of 975.5 feet by 31 March. If the late February basin-average snow water content is 3.0 inches or more (Category II drawdown, moderate-to-heavy spring runoff), the pool is lowered to the target elevation of 974.5 feet or lower by 31 March. Following the spring runoff, stored floodwaters are evacuated as quickly as possible with consideration for target stages at Wahpeton, North Dakota, and utilization of the 1,100 cfs channel capacity below White Rock Dam.

Summer inflows to Lake Traverse can be minimal to nonexistent, and evaporation can be 30 inches or more in one season. These uncertain conditions do not allow, in most years, a constant lake level to be maintained throughout the year following the spring runoff. To compensate for this situation, achievement of a reservoir target elevation of 976.8 feet is desirable following the release of spring runoff water. This allows Lake Traverse levels to be maintained near the conservation elevation of 976.0 feet during the recreation season in most years.

b. Mud Lake Reservoir. Mud Lake (between White Rock Dam and Reservation Dam) is regulated between the conservation pool elevation of 972.0 feet and the top of flood control elevation of 981.0 feet. During the drawdown of Lake Traverse, (above Reservation Dam) the Mud Lake pool is held as close to elevation 972.0 feet as possible. Mud Lake is not regulated below elevation 972.0 feet, except for habitat management purposes that do not conflict with flood control operation. However, during dry periods, evaporation will, at times, reduce the pool to levels below elevation 972.0 feet.

There is no winter drawdown for Mud Lake. During the winter drawdown for Lake Traverse, the level at Mud Lake will be held as near as possible to elevation 972.0.

During flood control operations, discharges from White Rock Dam are reduced to zero whenever the target stage at Wahpeton is exceeded. The Wahpeton target stage is 10 feet for a Category I drawdown and 12 feet for a Category II drawdown. If the reservoir pool exceeds elevation 981.0, the gates at White Rock Dam will be raised clear of the water surface until the pool again falls below elevation 981.0 (see **Exhibit D**). The maximum design pool is elevation 982.0 feet.

Details of the regulation are given in the following paragraphs. The regulation schedule for the Lake Traverse Project is shown graphically on **Plate 7-1** and in tabular form in **Exhibit D, Table D-1.**

7-04. Standing Instructions to the Project Resource Manager. (Refer to **Exhibit D** at the end of this manual.)

7-05. Flood Control. The effects of the water control plan for various flood events are discussed in **Chapter VIII**. The role of the Corps of Engineers in water control management for the Lake Traverse Project is discussed in **Chapter IX**. The regulation schedule for the Lake Traverse Project is shown graphically on **Plate 7-1** and in tabular form in **Exhibit D, Table D-1**.

a. Reservoir Drawdown, Late Winter.

1. Category I Drawdown, Normal Runoff Expected. A Category I winter drawdown of Lake Traverse, to target elevation 975.5 feet, begins on 1 March and is completed by 31 March (see **Plate 7-1 and Table D-1**). A drawdown to at least elevation 975.5 feet will occur in every year, unless Lake Traverse is already below elevation 975.8 feet on 1 March, in which case a Category I drawdown will

not be performed. Following a Category I drawdown, the target stage at Wahpeton is 10.0 feet for flood control operations (see **Table 7-1**). During the drawdown of Lake Traverse, the Mud Lake pool is held as close to elevation 972.0 feet as possible.

2. **Category II Drawdown, Moderate-to-Heavy Runoff Expected.** A Category II winter drawdown of Lake Traverse, to target elevation 974.5 feet or lower, begins on 1 March and is completed by 31 March (see **Plate 7-1 and Table D-1**). A Category II drawdown is done if the late February basin-average snow water content is greater than 3 inches. A Category II drawdown of Lake Traverse requires a concurrent drawdown of Orwell Reservoir to a level within the target range of 1048 to 1060 feet. The actual Orwell drawdown target elevation will be determined by Water Control based upon hydrologic conditions for the specific event. When a Category II drawdown is in effect, the target stage at Wahpeton is 12.0 feet (see **Table 7-1**). During the drawdown of Lake Traverse, the Mud Lake pool is held as close to elevation 972.0 feet as possible.

Table 7-1 Lake Traverse Project Flood Control Regulation			
Drawdown Category and Runoff Condition	**Lake Traverse[1] Target Drawdown Elevation in Feet**	**Orwell Reservoir Target Drawdown Elevation in Feet**	**Wahpeton Target Stage in Feet**
Category I Normal Runoff Conditions	975.5	None	10.0
Category II Moderate-to-Heavy Runoff Conditions[2]	974.5 or Lower[3]	1060.0-1048.0	12.0

1. Mud Lake Reservoir is not drawn down.
2. Snow cover with 3 or more inches of water equivalent.
3. Drawdown below elevation 974.5 feet is limited by exponentially decreasing discharge capacity due to the Reservation Dam sill elevation of 974.0 feet.

b. Spring Floods. Following the spring runoff period, water is stored to fill Lake Traverse Reservoir to the desired post-spring flood elevation of 976.8 feet. If flooding problems exist downstream, additional storage capacity is utilized to prevent or reduce damages to downstream communities.

When the level of Lake Traverse rises near elevation 976.8 feet, all the stop logs in Reservation Dam are removed. At the same time, discharge from White Rock Dam is governed by the requirement to maintain Mud Lake at elevation 972.0 feet, if possible, while not exceeding the target stage at Wahpeton or the 1,100 cfs channel capacity below the dam. Discharge from White Rock Dam is reduced to zero as necessary in an attempt to prevent exceedance of the Wahpeton target stage (see **Plate 7-1 and Table D-1**).

Once the reservoir elevation peaks and begins to fall, a maximum discharge of up to 1,100 cfs from White Rock Dam is maintained, as downstream conditions permit (while not exceeding the target stage at Wahpeton), until the pools reach elevation 976.8 feet (Lake Traverse) and 972.0 feet (Mud Lake). When the water level in Lake Traverse/Mud Lake reaches the full pool elevation of 981.0 feet, the gates at White Rock Dam are raised clear of the water surface until the pool again falls below elevation 981.0. The maximum design pool is 982.0 feet.

c. Late Spring, Summer, and Fall Floods. Following spring runoff, both pools are maintained at their respective elevations of 976.8 feet (Lake Traverse) and 972.0 feet (Mud Lake) by discharging inflow. The downstream channel capacity limit of 1,100 cfs and non-exceedance of the target stage at Wahpeton remain in effect. For late spring, summer, and fall flood events, regulate as for spring floods except the target stage at Wahpeton is fixed at 10 feet and there is no drawdown (see **Plate 7-1 and Table D-1**).

7-06. Recreation. Recreation is an important feature of the Lake Traverse Project. There are numerous homes and resorts around Lake Traverse Reservoir. There are also Corps of Engineers public recreation areas as described in **Paragraph 2-06**.

A reservoir target elevation of 976.8 feet on Lake Traverse is desirable following the release of spring runoff water. This allows reservoir levels to be maintained near the conservation elevation of 976.0 feet during most of the recreation season (see **Paragraph D-01.b.**).

Water levels in Mud Lake are managed in accordance with the Mud Lake Waterfowl Management Plan to maintain the quality of wetland habitat for waterfowl and other forms of wildlife (see **Paragraph 7-08**).

7-07. Water Quality. Following spring runoff, releases from the Lake Traverse Project will not be made unless necessary for flood control purposes or wildlife management activities (see **Paragraphs 3-06.f, 4-08, and 8-04**). Whenever water is released from the Lake Traverse Project, the municipal water utilities at Fargo and Moorhead are adversely affected. The water utilities prefer to avoid or minimize lengthy releases (except for discretionary wildlife and flood control drawdown), particularly during cold water periods (fall and winter). The biological assimilation of organic materials in the Bois de Sioux and Red Rivers is reduced by low water temperatures and the softening efficiency of the water treatment plants.

Short-duration, high-volume releases for flood control drawdown were made in March 1993 and March 1994. This proved to be acceptable to the Fargo and Moorhead water utilities. The short duration of these drawdowns, combined with the dilution from spring runoff in March and April, minimizes the exposure of the utilities to undesirable water quality. This period is also a time of lower water demand. Therefore, releases for winter drawdowns will be made in March, if required (see **Paragraph 7-05**).

Fargo and Moorhead water utility operators will be notified of impending releases from White Rock Dam. There is a 2- to 3-week travel time for low flows from White Rock Dam to Fargo-Moorhead. During high flow periods, the travel time is about 7 to 13 days. The water treatment plant operators can be contacted at the following numbers:

Mr. Ron Hendricksen	Fargo Water Treatment Plant	701-241-1469
Mr. Cliff McLain	Moorhead Water Treatment Plant	218-299-5470

A water quality monitoring program and diagnostic study are currently in progress. Their purpose is to develop water control strategies for management of water quality problems both at and downstream of the Lake Traverse Project.

7-08. Fish and Wildlife. Lake Traverse supports a productive and popular sport fishery that is economically important to the area. The regulation of Lake Traverse water levels can impose stress on fish, especially after winter drawdown. The lower winter pool level increases the likelihood of oxygen depletion due to the reduced volume of water and dissolved oxygen in the lake. Partial

fish kills have occurred. Fish habitat in Lake Traverse is limited by water quality, spawning habitat, and the presence of high populations of rough fish. Dense blue-green algae blooms in the summer detract from the aesthetic appeal of the lake and impose additional stress on fish.

Mud Lake does not support a consistent fishery because it is shallow and prone to winterkill. Mud Lake does, however, provide good quality wetland habitat for waterfowl and other forms of wildlife. The St. Paul District is a participant in the Mud Lake Management Group (MLMG), which was formed in 1986 to improve wetland habitat conditions in Mud Lake. The Mud Lake Waterfowl Habitat Management Plan, which was authored by the MLMG, included a drawdown of the lake during 1988-1989 to stimulate the growth of emergent aquatic vegetation and to control rough fish. The project included excavation of the approach channel to White Rock Dam to allow more complete drawdown of the marsh, and construction of a number of waterfowl nesting islands. The drawdown for vegetation management was successful and may be done again if conditions warrant. Water level management of Mud Lake will be conducted to avoid declines in water levels during warm periods to reduce the potential for outbreaks of avian botulism (see **Paragraph 3-06.e.**).

Releases for Mud Lake habitat management purposes will not be made other than in association with release of spring runoff until the Fargo and Moorhead water treatment plants are upgraded and low flow releases no longer cause problems with the municipal water supplies (see **Paragraph 3-06.f., 4-08, 7-07, and 8-04**).

7-09. Water Supply. The project does not have sufficient storage available to be a dependable long-term source of surface water for downstream water suppliers, especially during a dry period. Typically, the flow from Lake Traverse goes to zero in late summer and for several months during the winter.

Releases from the Lake Traverse Project affect the quantity and quality of water available for municipal water supply in the Red River (see **Paragraph 3-06.f., 4-08, 7-07, and 8-04**). Fargo, North Dakota, and Moorhead, Minnesota, are the only cities in the project area that currently depend on the Red River for a significant portion of their water supplies. Breckenridge, Minnesota, has an emergency intake in the Ottertail River, but the city uses its well system for municipal supplies. Fargo and Moorhead also have well systems, and Fargo has a diversion pipeline from the Sheyenne River. However, both cities prefer to use Red River water when it is available in adequate supply and quality. Other communities downstream of Fargo-Moorhead also use the Red River for at least a partial source.

7-10. Hydroelectric Power. There are no existing or planned hydropower projects in the Bois de Sioux River basin.

7-11. Navigation. Navigation is not an authorized purpose of the project.

7-12. Drought Contingency Plans. The drought contingency plan is in draft form (dated September 1992) and is a stand-alone document (see **Paragraph 1-03**). Copies of the plan are located at the Lake Traverse Project Office at White Rock Dam and in the District Office Water Control Section in St. Paul.

7-13. Flood Emergency Action Plan. The emergency action plan is a stand-alone document (dated October 1989) (see **Paragraph 1-03**). Copies of the plan are located at the Lake Traverse Project Office at White Rock Dam and in the District Office Water Control Section in St. Paul.

7-14. Deviation from Normal Regulation. Unusual circumstances that require minor deviations from the normal regulation plan must be approved by the District Engineer and Division Commander. For deviations that become necessary with little advance notice, Water Control will obtain verbal approval from the District Engineer and

the Division Commander with supporting documentation provided as soon as possible after the fact. Water Control personnel can authorize necessary short-term changes, under extreme emergency conditions, until approval from higher authority is obtained.

7-15. Discharge - Rate of Change. The following information is a guideline pertaining to flow reductions/increases from White Rock Dam. Emergency conditions, including flood control regulation, may warrant a substantial deviation.

a. Reducing Outflows. Unless flooding is imminent, outflow reductions are stepped to prevent stranding of aquatic life and to provide fish the opportunity to travel downstream to the Red and Ottertail Rivers. **Table 7-2**, below, is used for guidance on outflow reductions.

Table 7-2
Reducing Outflows, White Rock Dam
Suggested Rates of Change[1]

Flow Range	Rate of Change
From 1000+ cfs to 100 cfs	Reduce outflows over at least 2 days in approximately equal increments
From 100 cfs to 20 cfs	Reduce outflows over at least 3 days in at least 3 equal-ratio increments
From 20 cfs to 0 cfs	Reduce outflows over at least 4 days in approximately equal increments

1. Emergency conditions, including flood control operation, may warrant a substantial deviation from the values shown.

b. Increasing Outflows From Zero Discharge. Unless flooding is imminent, step outflow increases gradually to prevent channel scour, ice jams, and washout of vegetation. The following guidance is used for outflow increases. **Table 7-3**, below, is used for guidance on increasing outflows.

Table 7-3 Increasing Outflows, White Rock Dam Suggested Rates of Change[1]	
Flow Range	**Rate of Change**
From 0 cfs to 100 cfs	Increase outflow over at least 3 days in equal increments
From 100 cfs to 1000 cfs	Increase outflow over at least 3 days in approximately equal increments
1. Emergency conditions, including flood control operation, may warrant a substantial deviation.	

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. The primary benefits from the project are derived from flood control. Agricultural and urban flood control benefits are realized along the Bois de Sioux River and at the towns of Wahpeton, North Dakota, and Breckenridge, Minnesota. Secondary benefits include fish and wildlife and recreation.

8-02. Flood Control.

a. Spillway Design Flood. The construction of the Lake Traverse Project was completed in 1942. The hydrology studies conducted prior to construction did not include an estimate of the Probable Maximum Flood (PMF). Instead, the flood of April 1916, which raised Lake Traverse to elevation 981.0 feet, was used to design the project. The spillway was designed for a peak flow of 5,600 cfs.

b. Probable Maximum Flood. The Lake Traverse Project was constructed prior to the development of the current spillway design flood standards. The original design was not based upon PMF criteria. A PMF hydrograph was developed for the *Emergency Plan* study (see **Paragraph 1-03**) and has been incorporated into this manual for comparative purposes. The PMF was developed using a March 15th snowmelt-rainfall event. The computed peak inflow from the PMF was 170,000 cfs. Routing of the PMF through the reservoir

resulted (without dam failure) in a computed peak pool elevation of 988.4 feet and a maximum outflow through the spillway and over the dam of 169,500 cfs. The PMF overtops the dam by 2.4 feet. The PMF inflow hydrograph is presented on **Plate 8-1.**

c. Standard Project Flood. The Standard Project Flood has not been developed for the drainage area above the Lake Traverse Project.

8-03. Recreation. The current water control plan for the Lake Traverse Project provides dependable and stable summer lake levels. This benefits resort owners, lakeshore residents, and area commerce. Stable summer levels also reduce shoreline erosion and improve wildlife habitat (see **Paragraph 7-06**).

8-04. Water Quality. Releases from the Lake Traverse Project affect the quantity and quality of water available for municipal water supply in the Red River. The St. Paul District is monitoring the quality of water released from the Lake Traverse and Orwell Reservoir Projects, in conjunction with the municipal water utilities at Fargo and Moorhead. The monitoring program is helping to evaluate the effects of releases from the projects on water quality (see **Paragraphs 3-06.f, 4-08, and 7-07**).

8-05. Fish and Wildlife. The water control plan for Lake Traverse includes achieving a target lake level of 976.8 feet, if possible, following spring runoff. This target level provides sufficient lake volume to provide for aquatic habitat conditions during the growing season, and to limit the potential for winter fish-kills.

Mud Lake does not support a consistent fishery because it is shallow and prone to fish-kills. Mud Lake does, however, provide good quality wetland habitat for waterfowl and other forms of wildlife. The water control plan for Mud Lake includes implementation of the Mud Lake Waterfowl Habitat Management Plan (see **Paragraph 7-08**). This has resulted in improved wetland habitat conditions in Mud Lake and increased use by waterfowl. Intentional reductions of water level on Mud Lake during warm weather will be avoided if possible, in order to limit the potential for outbreaks of avian botulism (see **Paragraph 3-06.e.**).

8-06. Water Supply. The project does not have sufficient storage available to be a dependable long-term source of surface water for downstream water utilities. In addition, project waters are of poor quality, high in dissolved solids, of unpalatable taste and odor, and are costly to treat for municipal use (see **Paragraph 7-07 and 7-09**).

8-07. Hydroelectric Power. There are no existing or planned hydropower projects in the Bois de Sioux River basin.

8-08. Navigation. Navigation is not an authorized purpose of the project.

8-09. Drought Contingency Plans. The Drought Contingency Plan (DCP) provides a basic reference for water management decisions and responses to a water shortage in the Lake Traverse basin induced by climatological droughts. The DCP includes a plan formulation process for the release of low flows and an interagency coordination matrix. The drought contingency plan is in draft form (dated September 1992) and is a stand-alone document (see **Paragraph 1-03**).

8-10. Flood Emergency Action Plans. The *Emergency Plan* outlines procedures to be followed under various emergency conditions. The report includes: an emergency identification plan, an emergency operations and repair plan, an emergency notification list, and an inundation map. The plan is dated October 1989 and is a stand-alone document (see **Paragraph 1-03**).

8-11. Frequencies.

a. Peak Annual Inflow Frequency. The probability of a given maximum annual daily-average inflow into the Lake Traverse Project is shown on **Plate 8-2**. Daily-average inflows were calculated by use of the storage equation [Inflow-Outflow = Storage Change] using project pool elevations and outflows from 1942 through 1993.

b. Pool Elevation Frequency. The annual probability of a given project pool elevation is presented on **Plate 8-3**. This curve was developed for the period 1942 through 1993. Note that, depending on the project pool elevations, the control shifts from Reservation Dam to White Rock Dam. The data used to develop the curve reflects the maximum project pool elevation regardless of whether it was recorded at Reservation Dam or White Rock Dam.

c. Discharge/Stage-Frequency Curves. The discharge-frequency curve for U.S.G.S. gage No. 05050000, located 300 feet downstream of White Rock Dam, is shown on **Plate 8-4**. A small drainage ditch enters the channel just upstream of the gage. A stage-frequency curve for the Red River of the North at Wahpeton, North Dakota, is shown on **Plate 8-5**. A stage-frequency curve, rather than a discharge-frequency curve, is used at Wahpeton because of the

significant effects of ice jams in this area. This curve was developed in conjunction with a Federal Emergency Management Agency (FEMA) study in 1990 (see **Paragraph 1-03**). Weibull plot positions were used in place of Median plot positions in accordance with the FEMA guidelines in place at that time.

8-12. Control Points. The only control point below the project is at Wahpeton, North Dakota and Breckenridge, Minnesota. The project is regulated during flood periods for a target stage of 10 or 12 feet at U.S.G.S. gage No. 05051500 at Wahpeton (see **Paragraph 7-05**).

8-13. Other Studies.

a. Examples of Regulation. Several studies have been completed to determine the effectiveness of the present regulation plan for the Lake Traverse Project. These studies include:

(1) *Problem Appraisal Report, Operation Plan Evaluation, Lake Traverse*, U.S. Army Corps of Engineers, St. Paul District, January 1987.

(2) *Operation Plan Evaluation and Environmental Assessment, Lake Traverse, Bois de Sioux River and Orwell Reservoir*, U.S. Army Corps of Engineers, St. Paul District, April 1994.

b. Channel and Floodway. The Bois de Sioux River Channel was constructed as part of the Lake Traverse Project. The channel was built to provide sufficient outlet capacity for the project. From White Rock Dam to the mouth of the Rabbit River (about 18 miles), the channel is designed for 1,100 cfs. From the Rabbit River to the end of the channel (6 miles south of Wahpeton), the capacity is 2,000 cfs.

The dry years of 1988, 1989, and 1990 allowed dense vegetation to become well established in the channel bottom. A study conducted by the St. Paul District in 1989, to assess the performance of the channel as designed, demonstrated that the cross sectional area of the channel has changed very little since completion of the project. In addition, the study showed that the low beaver dams do not significantly affect flood stages. Vegetation in the channel, however, does reduce the channel capacity due to increased friction factors, particularly following dry years.

Dense vegetation in some sections of the channel affects the channel discharge capacity significantly. The vegetation significantly increases channel friction and causes a shift in the stage-discharge relationship. An analysis of historic stage and

discharge records revealed that, when channel bottom vegetation was well-established during drought periods, the channel friction increased substantially. During wet periods, the vegetation in the channel bottom is largely drowned out, thereby reducing channel friction.

In the winter of 1991-1992, the St. Paul District used a tracked vehicle to mechanically crush vegetation in the channel bottom downstream of White Rock Dam. Early thaws prevented treatment of much of the channel. Mechanical crushing of cattail severs the old stems, which serve as air vents for the roots when water returns in the spring. Mechanical crushing, followed by inundation, greatly reduces cattail density by depriving the roots of oxygen. Chemical control of vegetation in the channel was considered in the spring of 1992, but was not done because of the need to make releases to draw down the Lake Traverse Project. Any herbicides applied to the channel could have been transported downstream, causing potential problems with the municipal water supplies of Fargo and Moorhead.

In the future, vegetation in the Bois de Sioux River channel will be monitored. If there is excessive cattail and willow growth, mechanical crushing will be conducted during the winter. Crushing followed by flooding should adequately control vegetation in the channel. If not, other mechanical control methods will be applied. The stage-discharge relationship in the Bois de Sioux River will be monitored as well, to ensure that channel capacity is being maintained.

IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. The Corps of Engineers is the owner, operator, and regulator of the Lake Traverse Project. The St. Paul District Water Control Section has direct day-to-day responsibility for the regulation of flows from Reservation and White Rock Dams. The District Natural Resource Management Branch has responsibility for the operation and maintenance of the project (see **Chapter V and Exhibit D**).

b. Other Federal Agencies. The National Weather Service has the responsibility for all hydrologic forecasts within the Red River of the North basin. The U.S. Geological Survey collects data on the discharges at various stations within this basin (see map, **Plate 5-1**). The U.S. Fish and Wildlife Service, Soil Conservation Service, U.S. Geological Survey, U.S. Forest Service, and Environmental Protection Agency all have an ongoing interest in the regulation of the Lake Traverse Project.

c. State and County Agencies. The State and county agencies that have an interest in the regulation of the Lake Traverse Project are listed in **Table 9-1**.

9-02. Interagency Coordination.

a. Local Press and Corps Bulletins. Information concerning the regulation of the Lake Traverse Project is provided by the St. Paul District's Public Affairs Office (PAO) to the local news media in response to their requests. Additionally, the PAO provides news releases of an advisory nature to the local media regarding important aspects of project regulation. These releases do not provide public forecasts of river stages or flows, however, because such forecasts are a Congressionally mandated responsibility of the National Weather Service.

b. National Weather Service. Current readings from the reservoirs are supplied to the National Weather Service on a weekly basis or as requested. These readings include snow depth/water content, frost depths, precipitation, discharges and reservoir levels. The National Weather Service uses this information in developing their spring runoff outlook and flood forecasts.

c. U. S. Geological Survey. This agency receives data from its own and cooperative observer gages as well as from Water Control on a daily schedule and at other times as requested.

d. Other Federal, State or Local Agencies. Local interests include area resorts, and recreationists.

9-03. Interagency Agreements. The St. Paul District is a participant in the Mud Lake Management Group (MLMG), an organization formed to manage wetland habitat conditions in Mud Lake. The MLMG consists of representatives from the St. Paul District, the U.S. Fish and Wildlife Service, the South Dakota Game and Fish Department, the Minnesota Department of Natural Resources, lakeshore landowners, and local sportsmen's groups. The St. Paul District is signatory to the Mud Lake Waterfowl Habitat Management Plan, and is responsible for water level management and vegetation monitoring aspects of the plan. In addition to the Mud Lake plan, there is an understanding between the St. Paul District and the Minnesota Department of Natural Resources that in all river regulation matters affecting State interests, issues will be resolved through consultation.

9-04. Commissions, River Authorities, Compacts and Committees. A petition was filed in September 1987 for the formation of the Bois de Sioux Watershed District in Minnesota. A public hearing concerning the formation of the district was held on January 11, 1988, in Wheaton, Minnesota. The Minnesota Board of Water and Soil Resources approved the formation of the Bois de Sioux Watershed District in May 1988. In 1990, the district prepared an overall plan for soil and water resources management in the watershed for the 10-year period through the year 2000.

Other organizations and governments that have an interest in water control activities in the basin are listed in **Table 9-1.**

Table 9-1
Organizations With an Interest in Water Control Activities

NATIVE AMERICAN
Sisseton-Wahpeton
FEDERAL
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency
Federal Emergency Management Agency
MINNESOTA
Department of Natural Resources
Pollution Control Agency
Board of Water and Soil Resources
Wilkin County
Traverse County
Bois de Sioux Watershed District
County Soil and Water Conservation Districts
County Drain Conservation Districts
NORTH DAKOTA
State Water Commission
Game and Fish Department
State Conservationist
Richland County
Richland County Water Management District
SOUTH DAKOTA
Department of Water and Natural Resources
Division of Water Quality
Division of Project and Community Development
Department of Game, Fish, and Parks
Roberts County
INTERSTATE
Minnesota-South Dakota Boundary Waters Commission
Tri-State Agreement (to manage waters of the Red River of the North)
Red River Valley Watershed Board

9-05. Reports. Table 9-2 presents a listing of reports compiled by Water Control regarding the regulation of the Lake Traverse Project. These reports are in accordance with Engineering Manual No. 1110-2-3600. Blank copies of the necessary forms are keep in the Water Control Section.

Table 9-2

Reports

Report Name	Date Required	Form Number
Compiled by Water Control		
Annual Reservoir Summary	30 September	NCS-18
Reservoir Status Bulletin	End of Month	Computer Generated
Gage Records	As Needed	Computer Archived
Compiled by Field Office for the Water Control Center		
Monthly Log Sheet	End of Month	NCS-64
Weekly Gage Charts	Monday, a.m.	Recorder Chart
Snow Reports and Frost Reports	December 7 to March 30	NCS-430 NCS-58
Emergency Reports when Required or Requested	Daily, 0800	By Phone
Other		
Monthly Climatological Report	End of Month	WS-E15

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

LAKE TRAVERSE PROJECT

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

LAKE TRAVERSE PROJECT

General

Total drainage area (Mud Lake and Lake Traverse	1,160 square miles
Drainage area Mustinka River basin	869 square miles

Lake Traverse Reservoir (Reservation Dam)

Flowage rights to elevation	983.0 feet
Water-surface elevation at full pool	981.0 feet
Water-surface elevation at design flood	982.0 feet
Capacity at full pool (981.0)	164,500 acre-feet
Capacity at maximum pool (982.0)	177,500 acre-feet
Capacity at conservation pool (976.0)	106,000 acre-feet
Reservoir area, conservation pool (976.0)	10,925 acres
Reservoir area at full pool (981.0)	12,425 acres
Reservoir area at maximum pool (982.0)	12,700 acres
Reservoir length	16.5 miles
Maximum reservoir width at conservation pool	1-3/4 miles

Reservation Dam

Type	Rolled-earth fill
Top elevation	980.0 feet
Total length of earth embankment (spillway) (road constructed to function as spillway)	9,100 feet
Top width (roadway)	26 feet
Maximum height	14.5 feet
Total volume of earth dam	188,000 cubic yards

Reservation Dam Spillway

Type	Grouted riprap weir
Crest elevation	974.0 feet
Net length of spillway crest	101.5 feet
Number of stop log sections	17
Height of Sections	7 feet
Width of sections (clear opening)	6 feet (15 interior bays) 5.75 feet (2 outer bays)
Elevation of top of stop logs	976.8 feet
Maximum discharge (design flood)	5,600 cfs
Elevation of walkway over spillway	981.0 feet

SUPPLEMENTARY PERTINENT DATA (continued)

LAKE TRAVERSE PROJECT

Reservation Dam Outlet Conduits

Size and Length	2-24 inch by 14-foot metal culverts (plugged with removable concrete plugs)
Invert elevation (intake and outfall)	970.0 feet
Discharge capacity with pool at conservation level	80 cfs
Control (inoperative[1])	Two Calco slide gates

Reservation Dam Stilling Basin

Type	Grouted derrick stone
Length	27.5 feet
Maximum width at end section	150 feet

Mud Lake Reservoir (White Rock Dam)

Flowage rights to elevation	983.0 feet
Water surface elevation at full pool	981.0 feet
Water surface elevation at maximum pool	982.0 feet
Capacity at full pool	85,000 acre-feet
Capacity at maximum pool (design flood)	95,500 acre-feet
Capacity at conservation pool (972.0)	6,500 acre-feet
Reservoir area at conservation pool (972.0)	3,850 acres
Reservoir area at full pool (981.0)	10,550 acres
Reservoir area at maximum pool (982.0)	10,725 acres
Reservoir length	7.5 miles
Maximum reservoir width at conservation pool	2.5 miles

White Rock Dam

Type	Rolled-earth fill
Crest elevation	986.0 feet
Total length of earth embankment	14,400 feet
Top width (roadway)	26 feet
Maximum height	16 feet
Freeboard above spillway design flood height	4.0 feet
Total volume of earth dam	329,200 cubic yards

(1) Damaged by ice. Gates removed when culverts were plugged.

SUPPLEMENTARY PERTINENT DATA (continued)

LAKE TRAVERSE PROJECT

White Rock Dam Spillway

Type	Gated concrete sill
Crest elevation	965.0 feet
Length of spillway crest	Three 13-foot bays
Elevation top of Tainter gates (closed)	981.0 feet
Design discharge	5,600 cubic feet per second

White Rock Dam Stilling basin

Type	Concrete apron with dentated sill
Length	34.07 feet
Maximum width at end sill	47 feet
Elevation of stilling basin floor	960.0 feet

Browns Valley Dike

Type	Rolled-earth fill
Crest elevation (earth dike section)	987.0 feet
Crest elevation (culvert section)	+/- 986.5 feet
Total length of earth embankment	3,700 feet
Top width	10.0 feet
Maximum height	16.0 feet
Freeboard above spillway design flood height	5.0 feet
Total volume of earth dike	+/- 93,000 cubic yards

Browns Valley Culvert

Type	Triple Concrete box
Size	Three 6-foot by 9-foot openings
Length	68.75 feet
Invert elevation (east or reservoir side)	971.0 feet
Invert elevation (west or Little Minnesota River side)	974.0 feet

EXHIBIT B

RELATED MANUALS AND REPORTS

LAKE TRAVERSE PROJECT

EXHIBIT B

RELATED MANUALS AND REPORTS

1. Early Reports. Prior reports for flood control and navigation aids date from about 1874 and include a number of printed documents and annual reports of the Chief of Engineers. These reports deal with investigations into the advisability of dredging; removal of obstructions; and construction of locks and dams on the Minnesota River, Lake Traverse, and the Red River of the North and its tributaries. In general, these early reports were favorable to dredging and removal of obstructions but were unfavorable to the construction of reservoirs with locks and dams as aids to navigation.

2. *Report of an exploration of the Territory of Minnesota in 1849*, Ex. Document #42, 31st Congress, by Captain John Pope, Corps of Topographical Engineers, 1850.

3. *Examination and Survey of the Minnesota River*, Ex. Document No. 76, 43rd Congress, 2nd Session, 1866 - 1867, under the direction of Major G. K. Warren, Corps of Engineers.

4. *Survey of Minnesota River, Big Stone Lake, and Lake Traverse*, House Document No. 75, 44th Congress, 1st Session, 1872, under the direction of Colonel J. N. Macomb, Corps of Engineers.

5. *Preliminary examination of Big Stone Lake and Lake Traverse*, House Document No. 71, 48th Congress, 2nd Session, (Unfavorable). This report examined the possibility of connecting the two lakes.

6. *Survey of Big Stone and Lake Traverse for Reservoirs*, includes plans for reservoir and estimate of cost, House Document No. 134, 55th Congress, 2nd Session, 1897 (unfavorable).

7. *Survey Report on Big Stone and Lake Traverse for Reservoirs*, House Document No. 539, 58th Congress, 2nd Session, 1904 (unfavorable recommendation).

8. Examination of the Bois de Sio ux River, Lake Traverse and Big Stone Lake, House Document No. 492, 60th Congress, 10th Session, 1908 (unfavorable). This report examined the possibility of diverting floodwaters from the Red River of the North basin into the Minnesota River.

9. *Examination and Survey of Lake Traverse*, House Document No. 1391, 61st Congress, 3rd Session, 1911. This report covered removing obstructions to navigation.

10. *Examination and Survey of the Red River of the North and its Headwaters in Minnesota and North Dakota*, House Document No. 616, 62nd Congress, 2nd Session, 1912. This report studied the use of storage reservoirs to improve navigation.

11. *Examination of Lake Traverse*, House Document No. 439, 64th Congress, 1st Session, 1915.

12. *Examination of Lake Traverse and Big Stone Lake*. House Document No. 199, 65th Congress, 1st Session, 1917. This report looked at flood control and the possibility of connecting and extending navigation on and between these lakes. Report favorable.

13. *Drainage and the Prevention of Overflow in the Valley of the Red River of the North*, P.T. Simons, F.V. King, U.S. Department of Agriculture, Bulletin No. 1017, 1922.

EXHIBIT C

PROPER MARKINGS FOR RECORDER CHARTS

LAKE TRAVERSE PROJECT

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.

REFERENCE OR OFFICE SYMBOL	SUBJECT
CENCS-ED-GH (1110-2-1400b)	Proper Marking of Recorder Charts

TO THRU CENCS-~~ED~~ CENCS-~~CO~~ FROM CENCS-ED-GH DATE 13 Dec 88 KWillis/mc/619 CMT 1

TO All Lockmasters, Park Managers, and Damtenders

1. Although a number of sites are marking their recorder charts properly, many are not. Water Control now has an 8-year backlog of charts that cannot be microfilmed because they are not properly marked. To mark them properly on site takes only an additional second or two, but it costs us hundreds of man-hours to redo incorrectly marked charts.

2. Please direct your personnel to do them properly the first time. Your cooperation is greatly appreciated.

3. Enclosed is a sample of the proper notation. If anyone has any questions please contact Water Control for clarification.

Edward G. Eaton

Encl

EDWARD G. EATON
Chief, Water Control

DA FORM AUG 80 2496 PREVIOUS EDITIONS WILL BE USED

★ U.S.G.P.O. 1986-490-003/43241

Proper Markings for Recorder Charts

Should Include

1. Elevation for at least three consecutive feet should be noted in order to set vertical scale.
2. M-N-M (Midnight-Noon-Midnight) should be noted in order to set the horizontal scale.
3. The date on which the observation was made should be noted.
4. The gage reading at the time the recorder was checked should be noted.

4a. Note: The recorder pen should be gently moved up and down to show when the reading was made.

5. The person recording the observation should initial and log the time of the observation, along with any other (tape, staff, etc.) observations.
6. The site name and number should be printed in large bold letters at both the beginning and ending of the recorder chart, along with the charts date.

Additional Comments:

Use a felt tip marker for your notation (regular pen and pencil are usually unreadable on microfilm). USE THIS SIZE LETTERING

Notations should be made at least once a week in order to insure proper documentation when copies made from microfilm rolls.

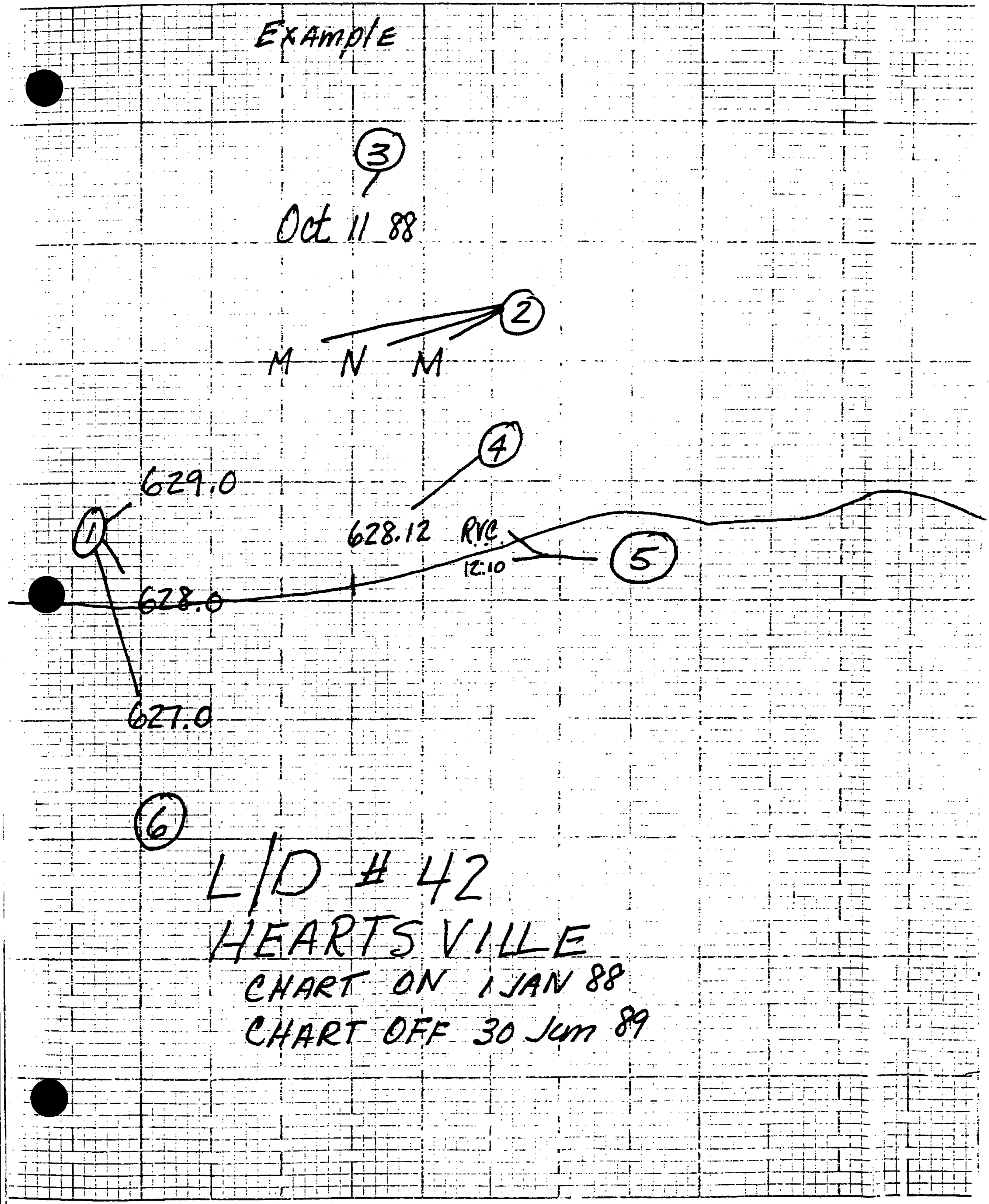

Example
3
Oct 11 88
2
M N M
4
629.0
1
628.12 RVC.
12:10
5
628.0
627.0
6
L/D # 42
HEARTSVILLE
CHART ON 1 JAN 88
CHART OFF 30 Jun 89

EXHIBIT D

STANDING INSTRUCTIONS TO THE PROJECT RESOURCE MANAGER

LAKE TRAVERSE PROJECT

EXHIBIT D

STANDING INSTRUCTIONS TO THE PROJECT RESOURCE MANAGER

LAKE TRAVERSE PROJECT

TABLE OF CONTENTS

TABLES

STANDING INSTRUCTIONS TO THE PROJECT RESOURCE MANAGER

D-01. General. These instructions will be followed at all times except when the operation is based on special directives issued by Water Control. Instructions contained in a special directive will be applicable for the period specified. The Project Resource Manager will maintain a log book of all such instructions received from the Water Control Section. The date and the time of call, the information, and the name of the regulator issuing the instructions will be recorded in the site log.

D-02. Normal Operation. The authorized conservation elevation for Lake Traverse is 976.0 feet. This figure is based on pre-project average lake levels.

Summer inflows to Lake Traverse can be minimal to non-existent and evaporation can be 30 inches or more in one season. These uncertain conditions do not allow, in most years, a constant lake level to be maintained throughout the year following the spring runoff. To compensate for this situation, achievement of a reservoir elevation of 976.8 feet is desirable following the

release of spring runoff water. This allows Lake Traverse levels to be maintained near the conservation elevation of 976.0 feet during most of the recreation season. The pool level for Mud Lake is lowered (if necessary) and held at the conservation elevation of 972.0 feet following the spring runoff.

A late winter drawdown (if necessary in Lake Traverse only) is started on 1 March and completed by 31 March to provide additional flood storage for the coming spring's runoff. Water Control will issue instructions (by 1 March) for the start of drawdown and set the rate of discharge required to meet the target elevation of 975.5 feet (Category I drawdown) or 974.5 feet or lower (Category II drawdown) by 31 March. A drawdown to at least elevation 975.5 feet will occur in every year, unless Lake Traverse is already below elevation 975.8 feet on 1 March. A Category II drawdown is done if the late February basin-average snow water content is 3 inches or greater.

Details of the regulation are given in the following paragraphs and in **Chapter 7**. Information on increasing or decreasing outflows from White Rock Dam can also be found in **Chapter 7**. The regulation schedule for the Lake Traverse Project is shown graphically on **Plate 7-1** and in tabular form in **Table D-1**.

D-03. Regulation for Floods.

a. Reservoir Drawdown, Late Winter.

1. Category I Drawdown, Normal Runoff Expected. A Category I winter drawdown of Lake Traverse to target elevation 975.5 feet, begins on 1 March and is completed by 31 March (see **Plate 7-1 and Table D-1**). A drawdown to at least elevation 975.5 feet will occur in every year, unless Lake Traverse is already below elevation 975.8 feet on 1 March, in which case a Category I drawdown will not be performed. Following a Category I drawdown, the target stage at Wahpeton is 10.0 feet for flood control operations (see **Table D-1**). During the drawdown of Lake Traverse the Mud Lake pool is held as close to elevation 972.0 feet as possible.

2. Category II Drawdown, Moderate-to-Heavy Runoff Expected. A Category II winter drawdown of Lake Traverse, to target elevation 974.5 feet or lower, begins on 1 March and is completed by 31 March (see **Plate 7-1 and Table D-1**). A Category II drawdown is done if the late February basin-average snow water content is greater than 3 inches. A Category II drawdown of Lake Traverse requires a concurrent drawdown of Orwell Reservoir to a level within the target range of 1048 to

1060 feet. The actual Orwell drawdown target elevation will be determined by Water Control based upon hydrologic conditions for the specific event. When a Category II drawdown is in effect, the target stage at Wahpeton is 12.0 feet (see **Table D-1**). During the drawdown of Lake Traverse the Mud Lake pool is held as close to elevation 972.0 feet as possible.

Table D-1
Lake Traverse Project
Flood Control Regulation

Drawdown Category and Runoff Condition	Lake Traverse[1] Target Drawdown Elevation in Feet	Orwell Reservoir Target Drawdown Elevation in Feet	Wahpeton Target Stage in Feet
Category I Normal Runoff Conditions	975.5	None	10.0
Category II Moderate-to-Heavy Runoff Conditions[2]	974.5 or Lower[3]	1060.0-1048.0	12.0

1. Mud Lake Reservoir is not drawn down.
2. Snow cover with 3 inches of water equivalent or greater
3. Drawdown below elevation 974.5 feet is limited by exponentially decreasing discharge capacity due to the Reservation Dam sill elevation of 974.0 feet.

b. Spring Floods. Following the spring runoff period, water is stored to fill Lake Traverse reservoir to the desired post-spring flood elevation of 976.8 feet. If flooding problems exist downstream, additional storage capacity is utilized, to prevent or reduce damages to downstream communities.

When the level of Lake Traverse rises near elevation 976.8 feet, all the stop logs in Reservation Dam are removed. At the same time, discharge from White Rock Dam is governed by the requirement to maintain Mud Lake at elevation 972.0 feet, if possible, while not exceeding the target stage at Wahpeton or the 1,100 cfs channel capacity below the dam. Discharge from White Rock Dam is reduced to zero as necessary in an attempt to prevent exceeding of the Wahpeton target stage.

Once the reservoir elevation peaks and begins to fall, maintain a maximum discharge of up to 1,100 cfs from White Rock Dam, as downstream conditions permit (while not exceeding the target stage at Wahpeton), until the pools reach elevation 976.8 feet (Lake Traverse) and 972.0 feet (Mud Lake). When the water level in Lake Traverse/Mud Lake reaches the full pool elevation of 981.0 feet, the gates at White Rock Dam are raised clear of the water surface until the pool elevation is below elevation 981.0.

c. Late Spring, Summer, and Fall Floods. Following spring runoff, maintain both pools at their respective elevations of 976.8 feet (Lake Traverse) and 972.0 feet (Mud Lake) by discharging inflow. The downstream channel capacity limit of 1,100 cfs and the target stage at Wahpeton remains in effect. For late spring, summer, and fall flood events, regulate as for spring floods except the target stage at Wahpeton is fixed at 10 feet, and there is no drawdown.

D-04. Regulation for Low-Flow Conditions. Flow should be maintained year-round in the Bois de Sioux River downstream of Lake Traverse to prevent desiccation of habitat and disruption of the invertebrate community. However, winter releases should not jeopardize the fishery in Lake Traverse by lowering the lake and reducing oxygen levels to dangerous levels. Lower pool levels on Lake Traverse reduce the water volume and thus the available dissolved oxygen.

All releases from White Rock Dam should be reduced gradually to minimize stranding of fish and invertebrates in the river (see **Paragraph 7-15**).

The recommended in-stream flow regimes for the Bois de Sioux River at White Rock Dam are listed in **Table D-2**. The minimum instream flows constitute an informal agreement between the St. Paul District and the Minnesota Department of Natural Resources.

Consult the Drought Contingency Plan for additional information (see **Paragraph 7-12**).

Releases from the Lake Traverse project cause taste, odor, hardness, and other problems with the municipal water supplies at Fargo, North Dakota, and Moorhead, Minnesota. Continuous low flow releases from the project should not be made until the municipal water treatment plants at Fargo and Moorhead are upgraded, and low flow releases from the project no longer cause water supply problems (see **Paragraph 4-08 and 7-07**).

Table D-2 Lake Traverse Project Low Flow Agreement[1] With the Minnesota Dept. of Natural Resources			
Lake Traverse Elevation, feet	**April 1-June 15**	**June 15-Sept. 30**	**Oct. 1 - March 31**
Above 976.8	50	50	40
976.8 - 976.0	25	15	10
976.0 - 975.5	15	10	5
Below - 975.5	10	5	5
Low flow releases from the project should not be made until the municipal water treatment plants at Fargo and Moorhead are upgraded, and low flow releases from the project no longer cause water supply problems.			

D-05. Emergency Operation. In the event of a failure of normal communication facilities, every effort will be made by the Resource Manager to maintain contact with the District Office. In such circumstances, the primary objective will be to ensure the safety of the structure and to provide the most effective regulation of the project by following the regulation schedule as shown on **Plate 7-1** and in **Table D-1**. During such emergency operations, the schedule will be followed until contact with the

District Office is re-established. The Resource Manager will need to keep informed concerning effects of the reservoir releases on downstream damage areas. If an emergency arises during non-duty hours, the Resource Manager will contact one of the following people:

Contact Personnel		Home Phone
1.	Gordon Heitzman	612 772-3150
2.	Edward Eaton	612 754-2640
3.	Bonnie Montgomery	612 450-0905
4.	Helmer Johnson	612 633-7791

D-06. Collection of Data. The regulation and proper operation of the project require the collection and evaluation of several meteorological, hydraulic and hydrologic parameters. The following paragraphs discuss the collection of various types of data. Consult **Chapter V** for additional information.

a. River and Reservoir. River and reservoir stage data will be obtained from all gages in the vicinity of the dam site and other pertinent locations either in or adjacent to the reservoir. The data will be collected by recording or non-recording gages at frequencies varying with the conditions as determined by Water

Control. The official pool and tailwater gages are continuous recorders with tapes (see **Table 5-1**). Pool and tailwater readings will be recorded at 8:00 a.m. daily unless otherwise directed by Water Control. Other data is collected by Water Control as noted in **Chapter V.**

b. Precipitation. An NWS continuous recording rain gage is used at the White Rock Dam to report the daily precipitation. The recorder chart is mailed monthly to the National Weather Service in Minneapolis.

c. Snow Depth and Moisture Content. During the winter, regular measurements of snowfall at White Rock Dam shall be made on Mondays and reported to Water Control, unless otherwise directed. To determine the water content of the snow, follow the instructions in "Instructions for Climatological Observers," U.S. Department of Commerce, Weather Bureau, Circular B.

d. Wind and Temperature. The minimum and maximum air temperatures, as well as wind speed and direction, are noted and logged at White Rock Dam at 8:00 a.m. daily.

e. Water Quality. Project personnel may be asked, on occasion, to assist District office personnel or contractors to collect water samples and or water quality measurements in the project area.

f. Annual Snow Survey. Prior to the spring break-up, the Resource Manager will conduct a snow survey within the area surrounding the project at stations and on dates selected by Water Control.

At least four samples are to be taken at each station. The average snow depth and water content of snow in inches will be recorded on an NCS Form 430. In addition to the snow samples, notes will be made on the general conditions of snow and ice cover in timber areas, fields, river channels, and ditches. Observations will be made both at the stations where measurements are made and between the stations. Frost depth information, if available, will also be reported to Water Control. If an appreciable amount of snow falls after the survey is completed, another survey may be required.

The snow survey stations are listed in **Table 5-3** and shown on **Plate 5-2**. Any deviation from the sites listed in **Table 5-3** will be reported with an explanation. A standard snow sampling tube is maintained at the project site. Standard NCS Form 430 will be completed for each site and mailed to Water Control following completion of the survey.

g. Supplemental Readings. Extra readings of the precipitation or other gages shall be made upon instructions from Water Control. These reports will cover data on the following subjects:

(1) Stage data. Special gage readings of the river or reservoir level or other tributary gages as requested.

(2) Precipitation. The 24-hour totals are reported to Water Control daily at 8:00 a.m. Extra readings, for time periods specified by Water Control, will be made when requested. The 24-hour total always includes the amounts reported in any extra readings.

(3) Damage report. A report on damage caused by flooding, wave or ice action, low water, etc., may be requested from time to time by Water Control.

D-07. Reports.

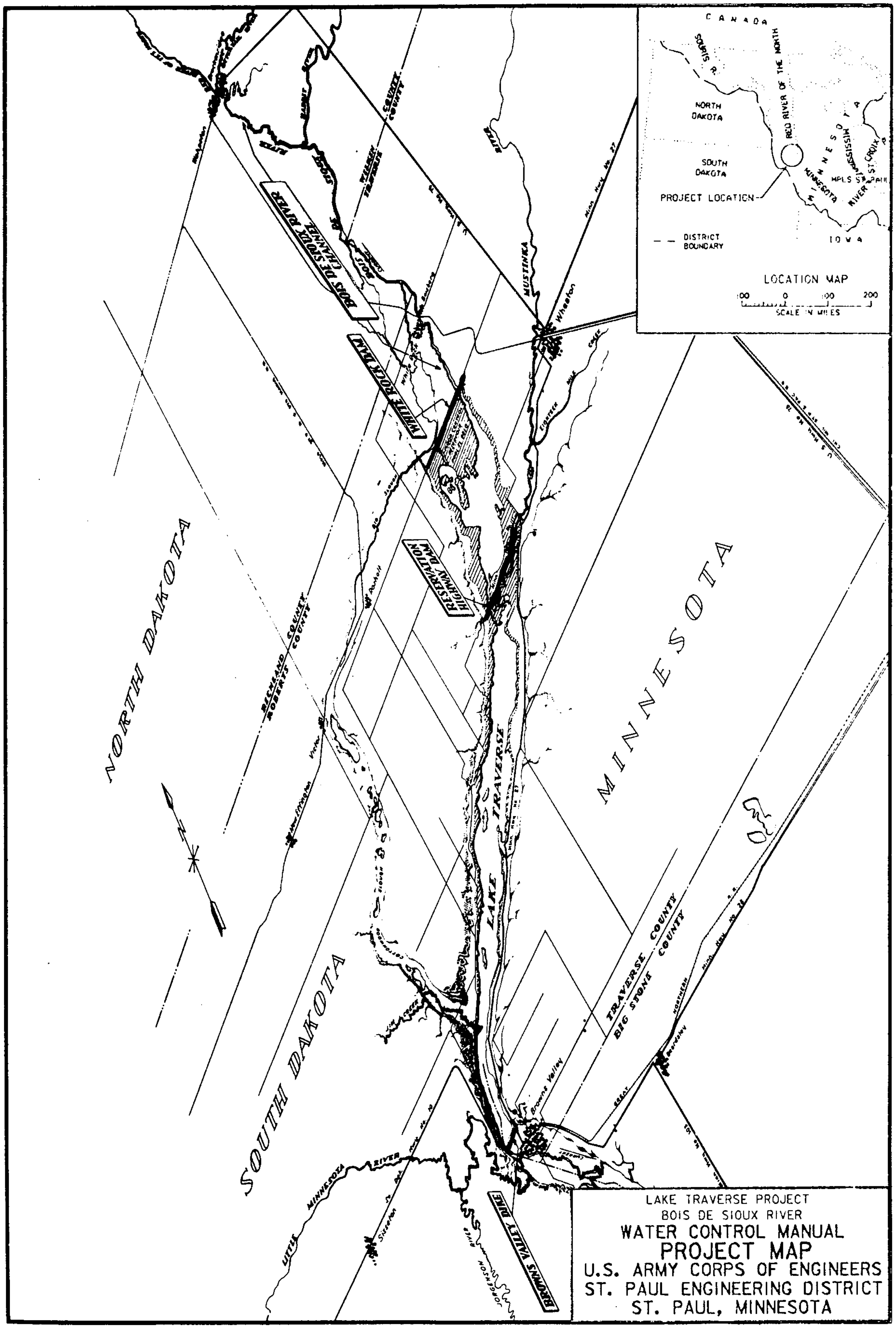
a. Monthly Log Sheet. NCS Form 64, "Monthly Log Sheet," shall be used to record all project gate openings, gage readings, reservoir discharge, and local weather conditions. This record is prepared in duplicate and the original shall be mailed directly to Water Control after the last entry has been made at the end of the month.

b. Gage Recorder Charts. All continuous recording gage charts will be removed every six months unless instructions to the contrary are given by Water Control. At least weekly, the following information is to be noted on the chart: three vertical scale elevations, three horizontal scale times, date, gage height, site name and number, together with the initials of the observer. The aforementioned information will also be recorded whenever the gage charts are removed, replaced, or reset. These notations will enable Water Control to make whatever corrections are necessary to the record. Notations will be made in accordance with the guidance shown in **Exhibit C**.

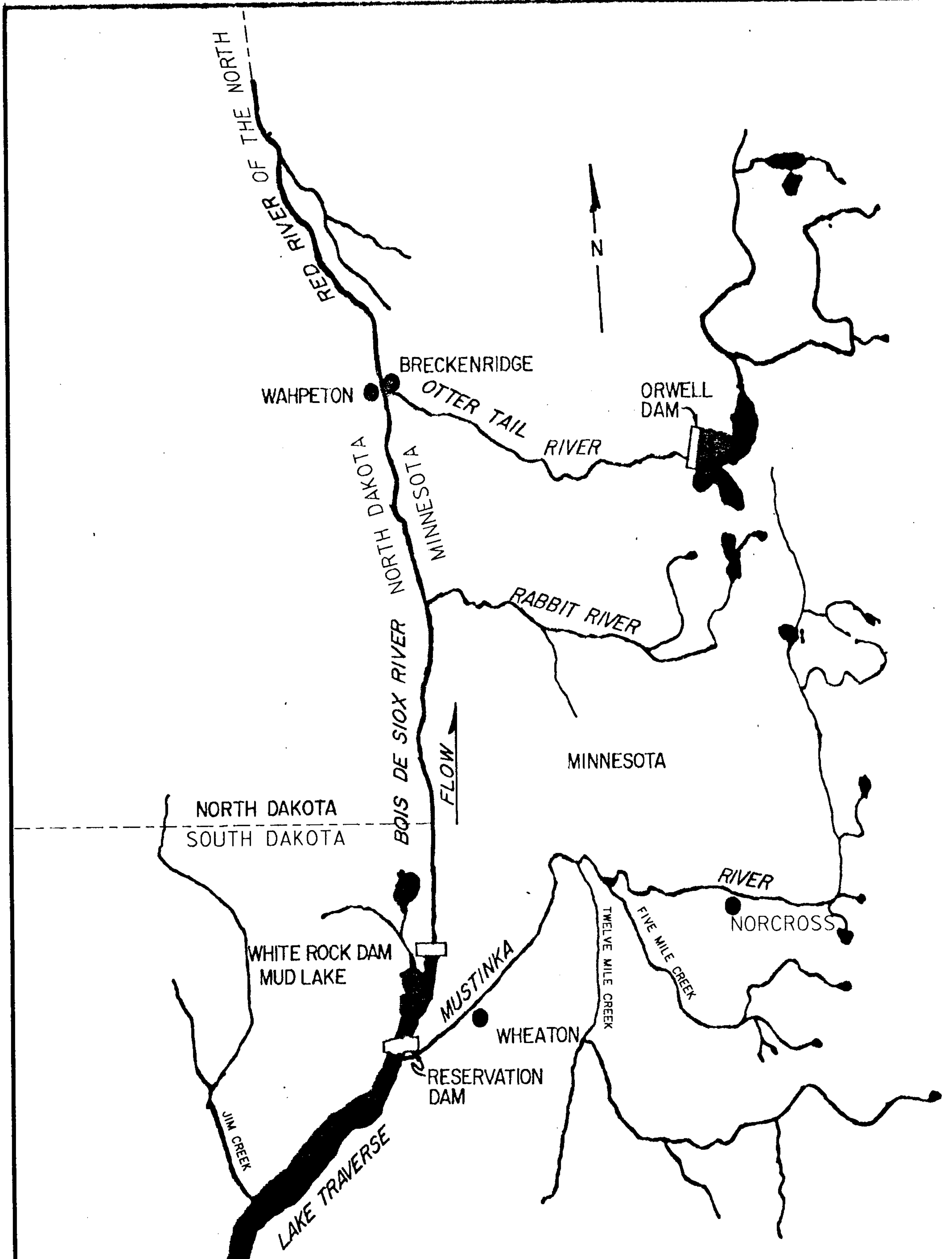
c. Telephone Reports. Telephone communication with Water Control will be made on a regular schedule to provide the hydrologic data required for regulation. Contact will take place every Monday, Wednesday and Friday or as requested by Water Control. The report will include the water surface elevation for

the pool and tailwater at both dams, the discharge from the dams, the wind speed and direction, and the precipitation during the previous 24 hours ending at 8:00 a.m. At the time of the report, additional information concerning weather, icing, and operational problems may be transmitted to Water Control.

d. Monthly Precipitation Report. Recorder charts from the rain gage will be sent monthly to the National Weather Service Forecast Office at 6301 34th Avenue South, FAA Building, Minneapolis, Minnesota 55450.

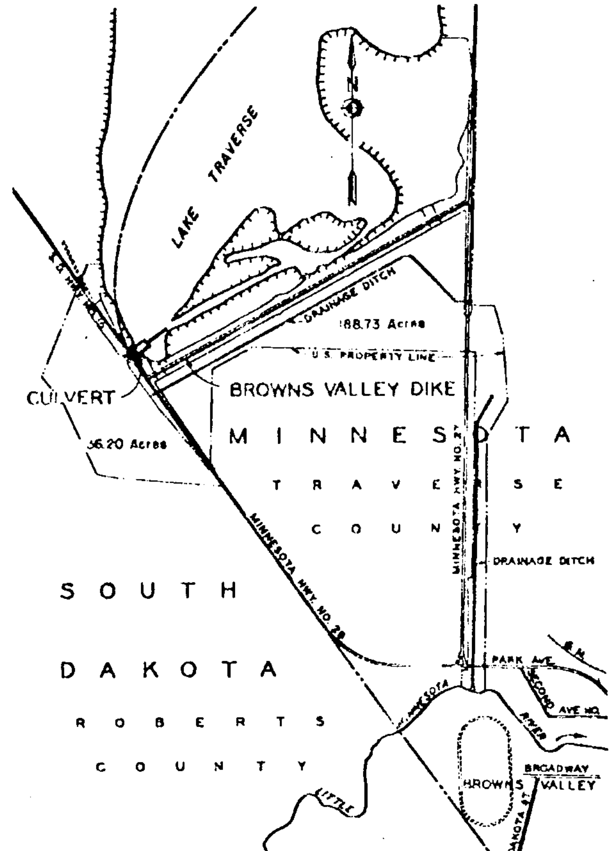


LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
PROJECT MAP
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

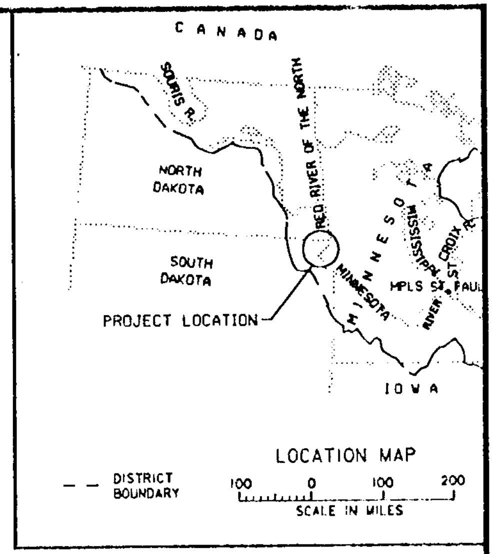


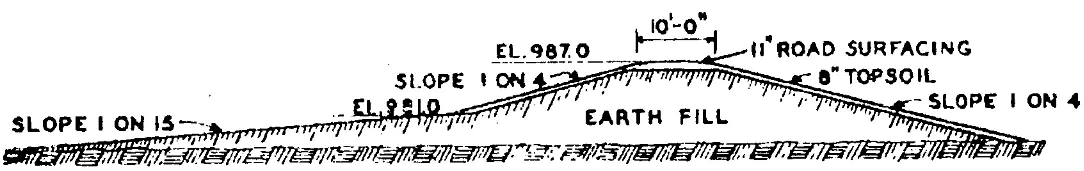
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
GENERAL LOCATION MAP
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

PLATE 2-2

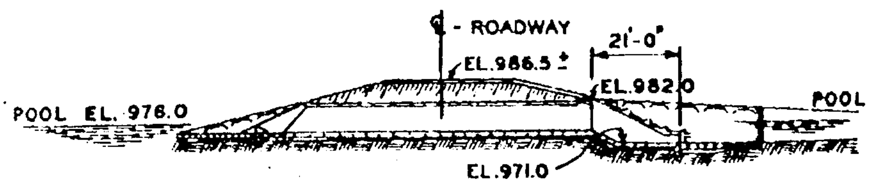


PLAN
BROWNS VALLEY DIKE & CULVERT
400 0 400 800 1200
SCALE IN FEET





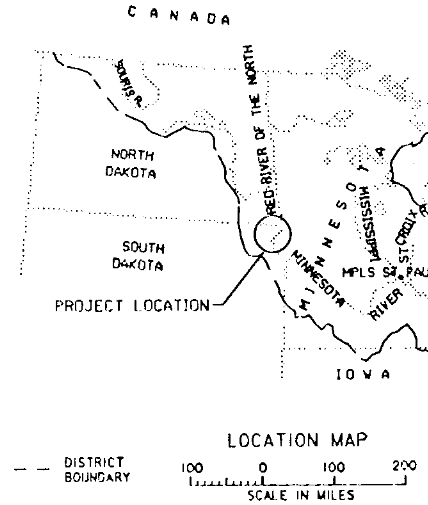
EARTH DIKE SECTION
BROWNS VALLEY
0 10
SCALE IN FEET



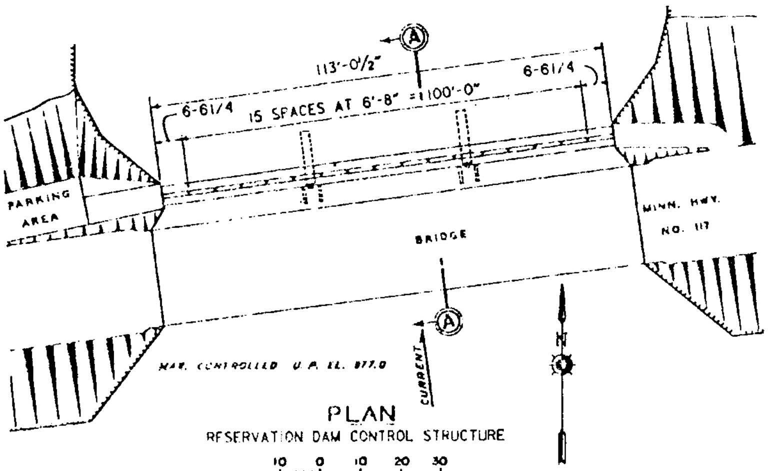
CULVERT SECTION
BROWNS VALLEY
0 20
SCALE IN FEET

ELEVATIONS ARE REFERENCED TO 1912 M.S.L.

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
BROWNS VALLEY DIKE AND CULVERT
GENERAL PLAN AND CROSS SECTIONS
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

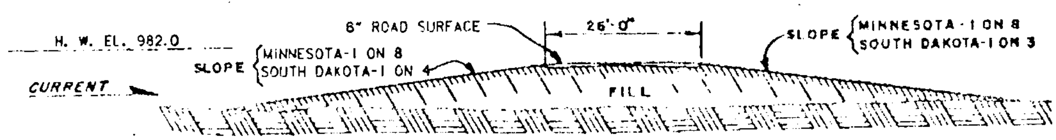


LOCATION MAP



PLAN

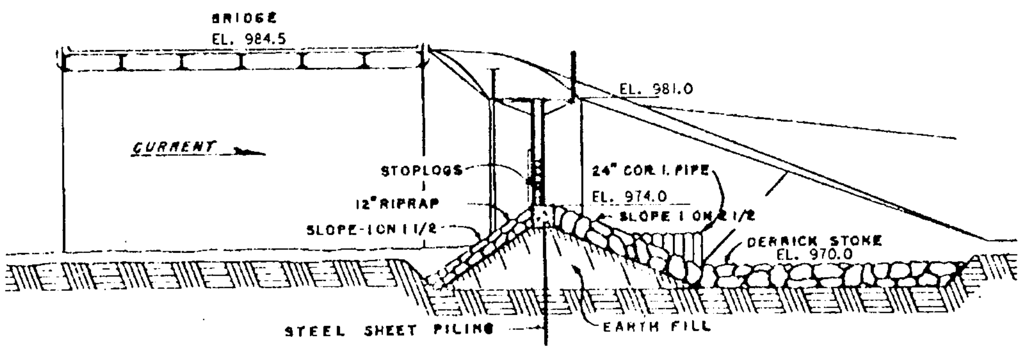
RESERVATION DAM CONTROL STRUCTURE



HIGHWAY SECTION

RESERVATION DAM HIGHWAY
MN. HWY. NO. 117

10 0 10 20 30
SCALE IN FEET

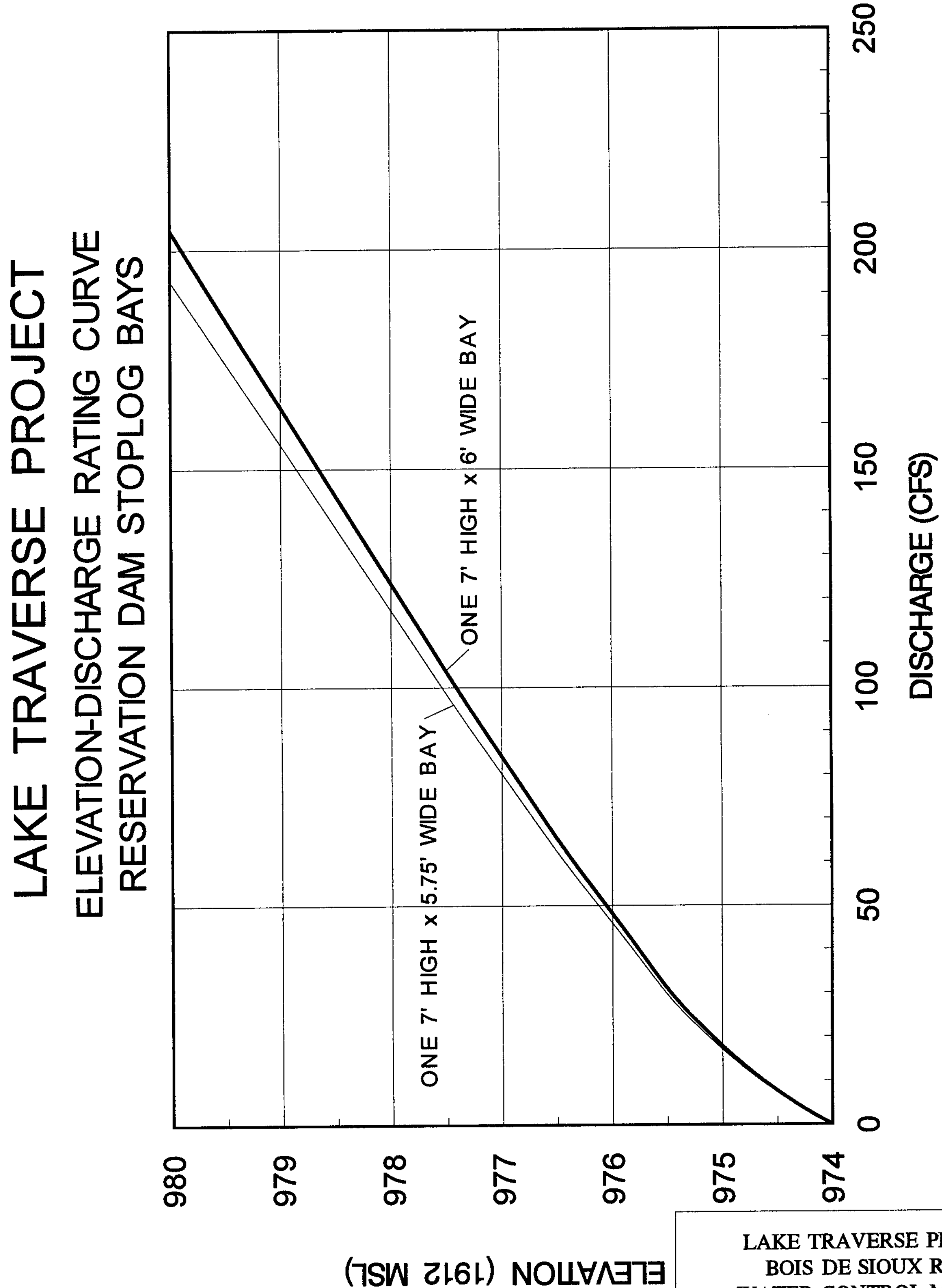


SECTION A-A

5 0 5 10 15
SCALE IN FEET

ELEVATIONS ARE REFERENCED TO 1912 M.S.L.

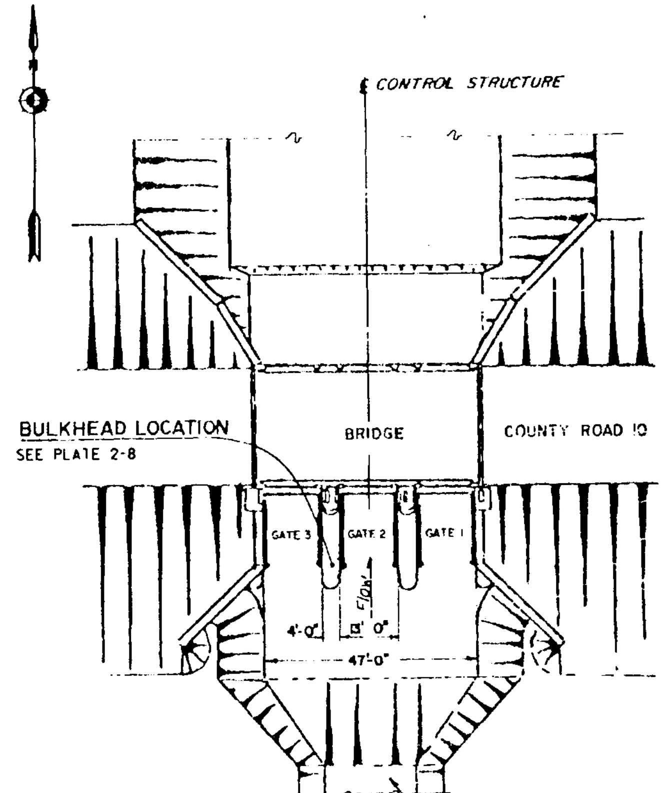
LAKE TRAVERSE
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
RESERVATION DAM
GENERAL PLAN AND
CROSS SECTIONS
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA



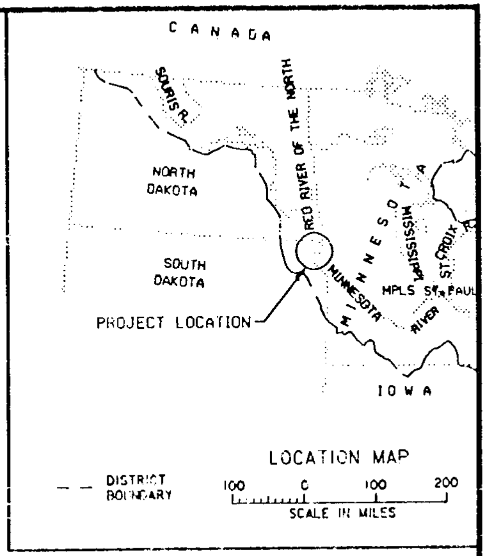
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

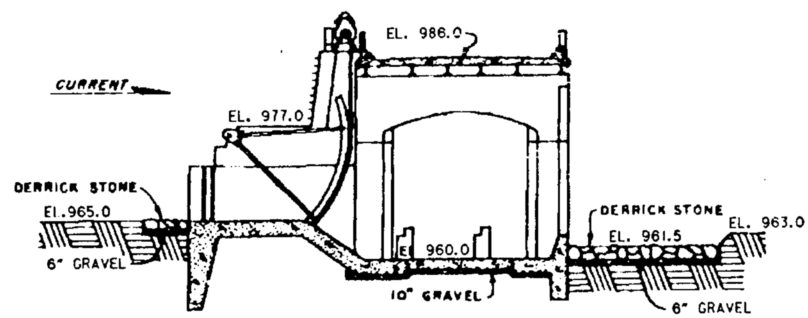
ELEVATION-DISCHARGE
RESERVATION DAM
STOPLOG BAYS

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

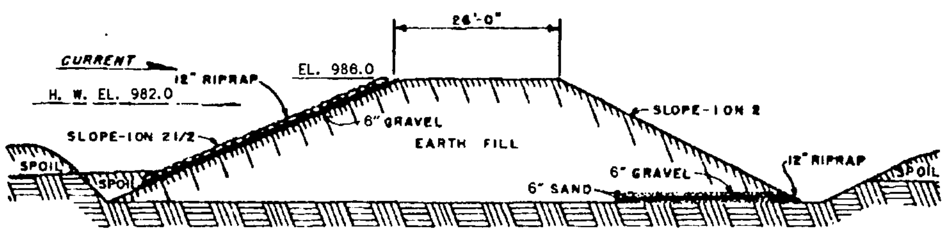


PLAN
CONTROL STRUCTURE
WHITE ROCK DAM
10 5 0 10 20
SCALE IN FEET





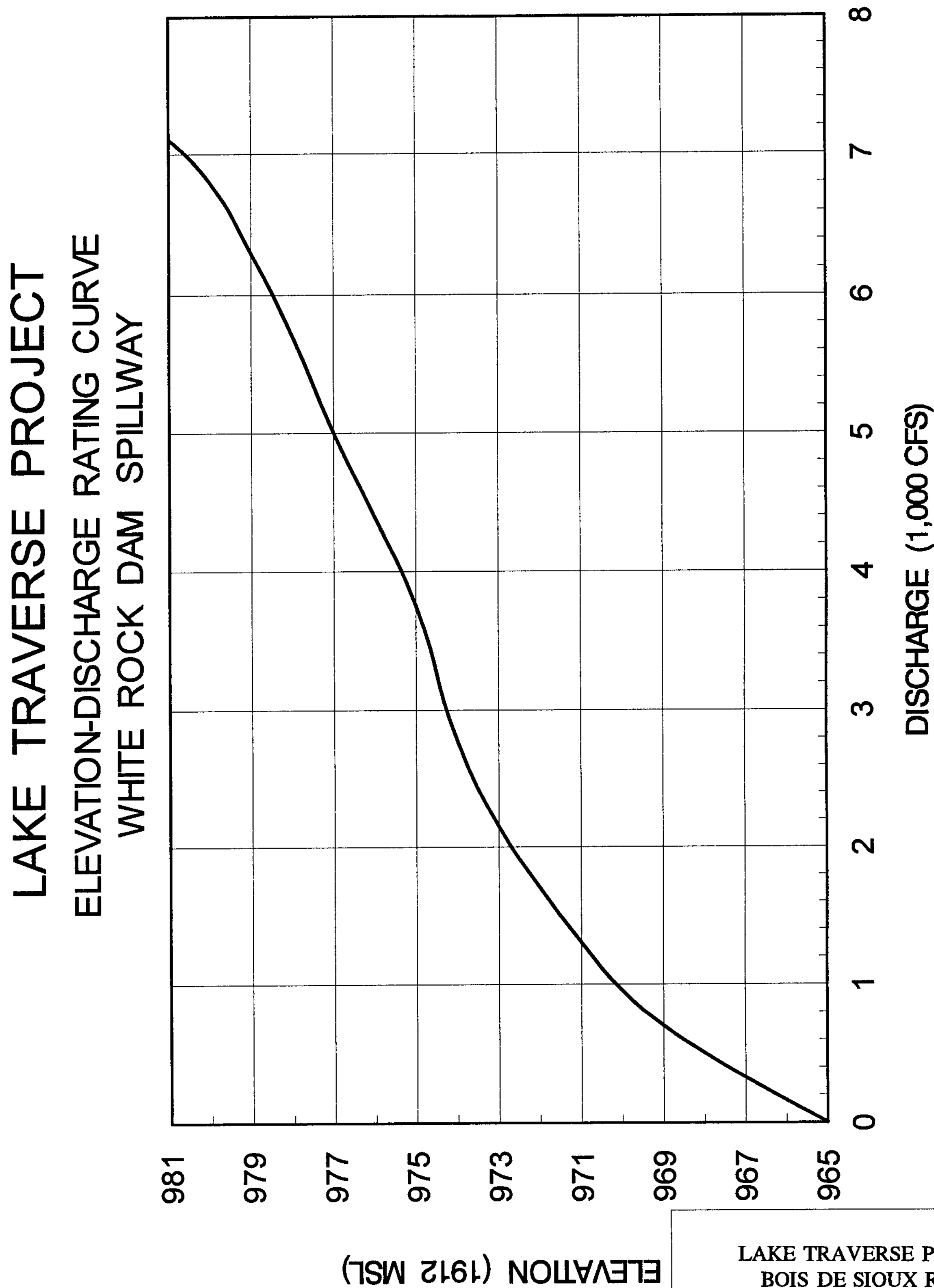
SECTION
TAINTER GATE
10 0 10 20 30
SCALE IN FEET



EARTH DIKE SECTION
WHITE ROCK DAM
10 0 10 20 30
SCALE IN FEET

ELEVATIONS ARE REFERENCED TO 1912 M.S.L.

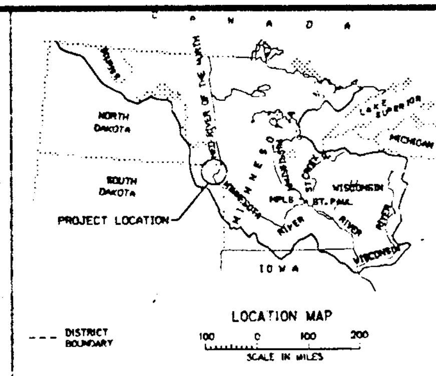
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
WHITE ROCK DAM
GENERAL PLAN AND
CROSS SECTIONS
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA



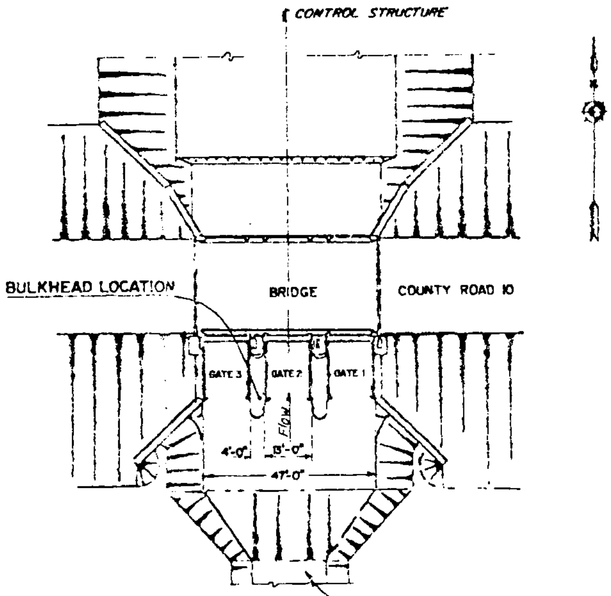
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

ELEVATION-DISCHARGE
WHITE ROCK DAM SPILLWAY

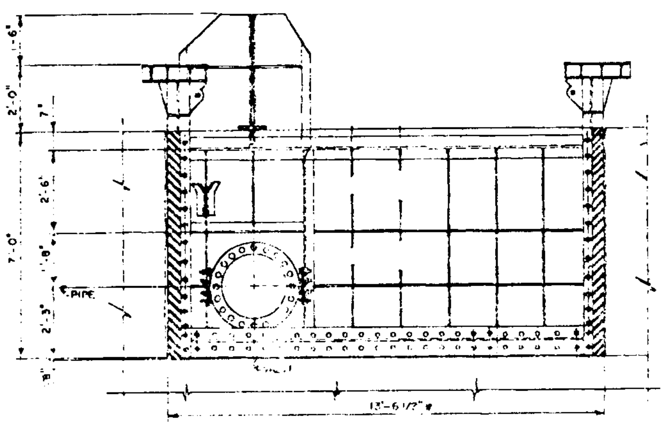
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



LOCATION MAP

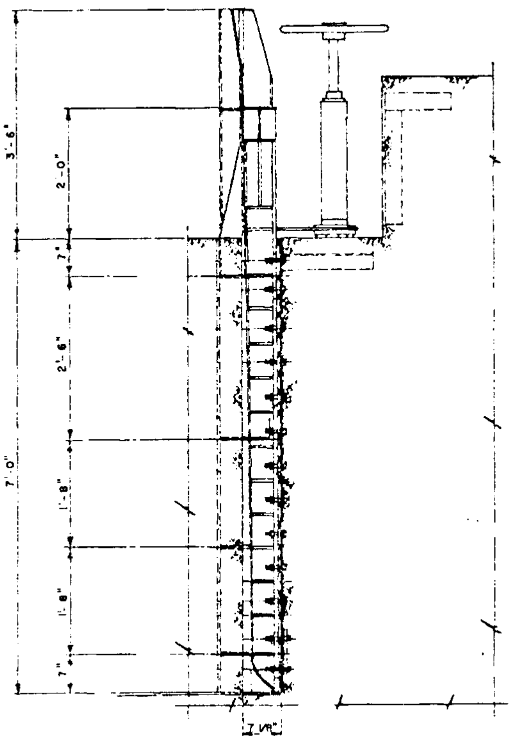


PLAN
WHITE ROCK DAM
10 5 0 10 20
SCALE IN FEET



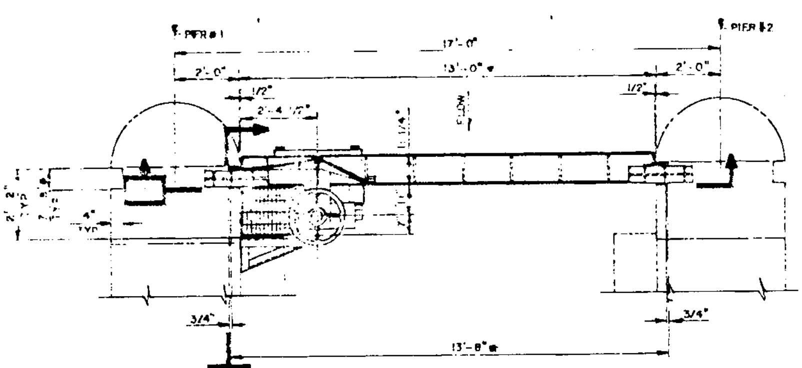
SECTION 1

SCALE: 1/2" = 1'-0"



SECTION 2

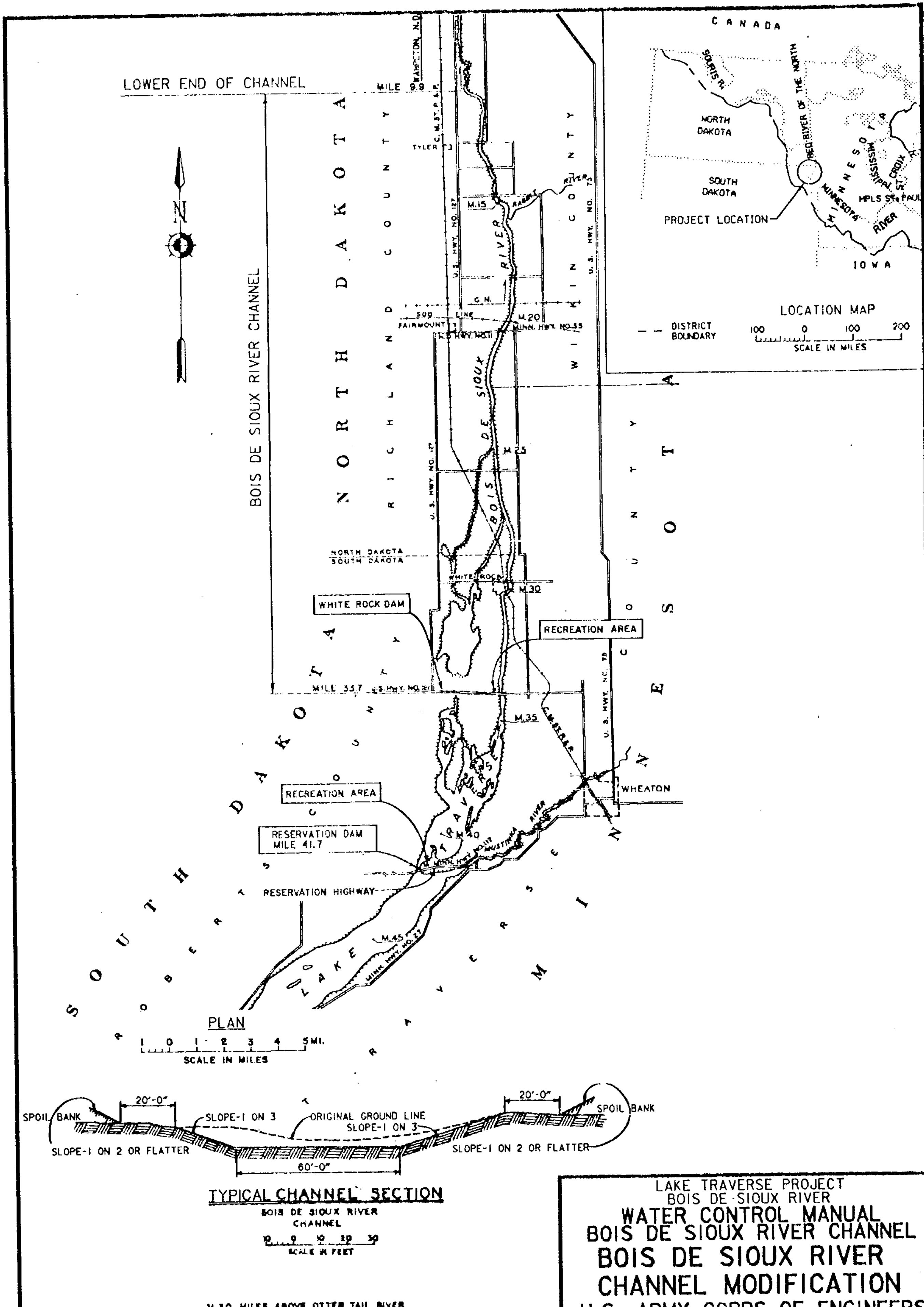
SCALE: 1" = 1'-0"



BULKHEAD PLAN

SCALE: 1/2" = 1'-0"

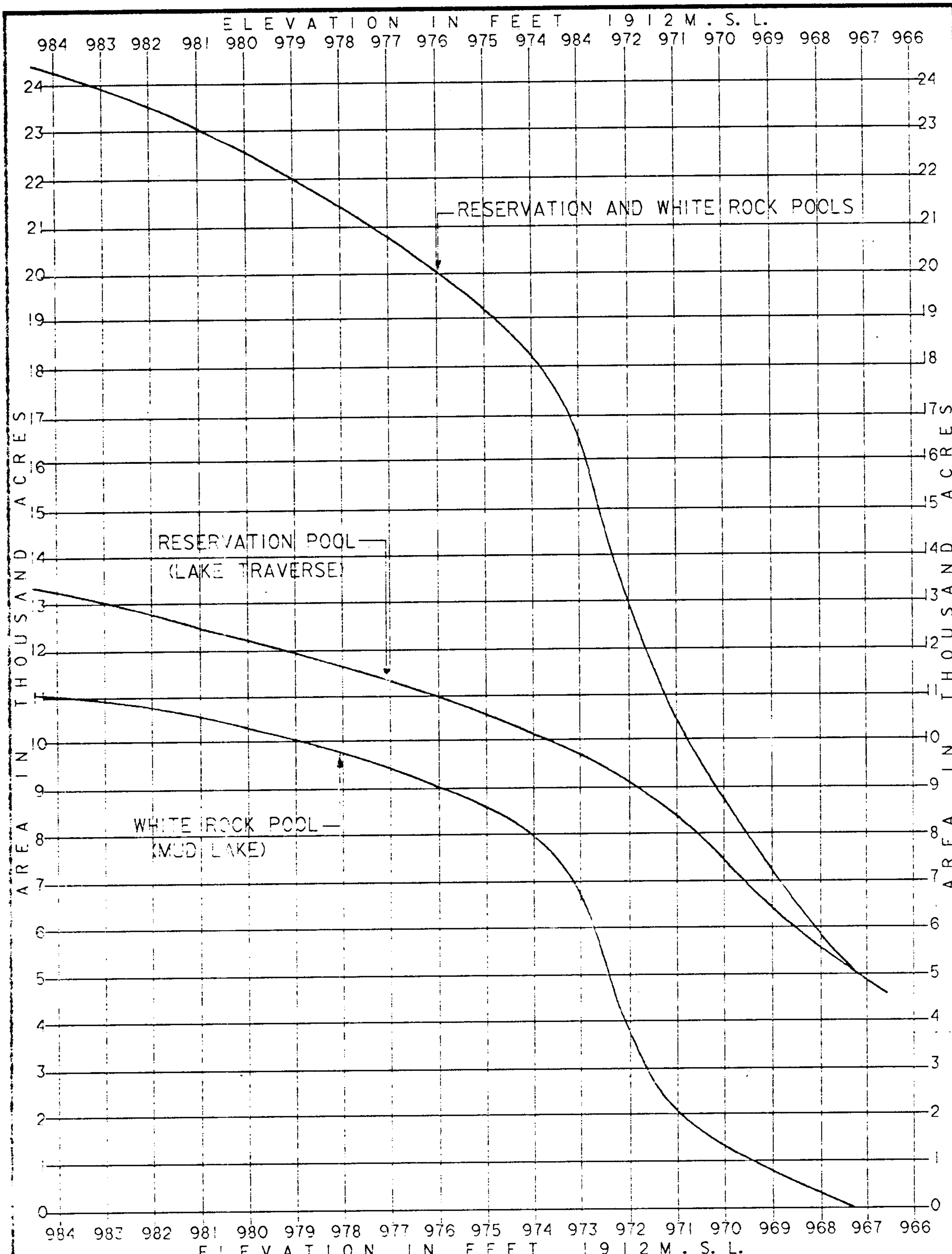
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
WHITE ROCK DAM, LOW FLOW BULKHEAD
GENERAL PLAN AND CROSS SECTIONS
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
BOIS DE SIOUX RIVER CHANNEL

BOIS DE SIOUX RIVER
CHANNEL MODIFICATION

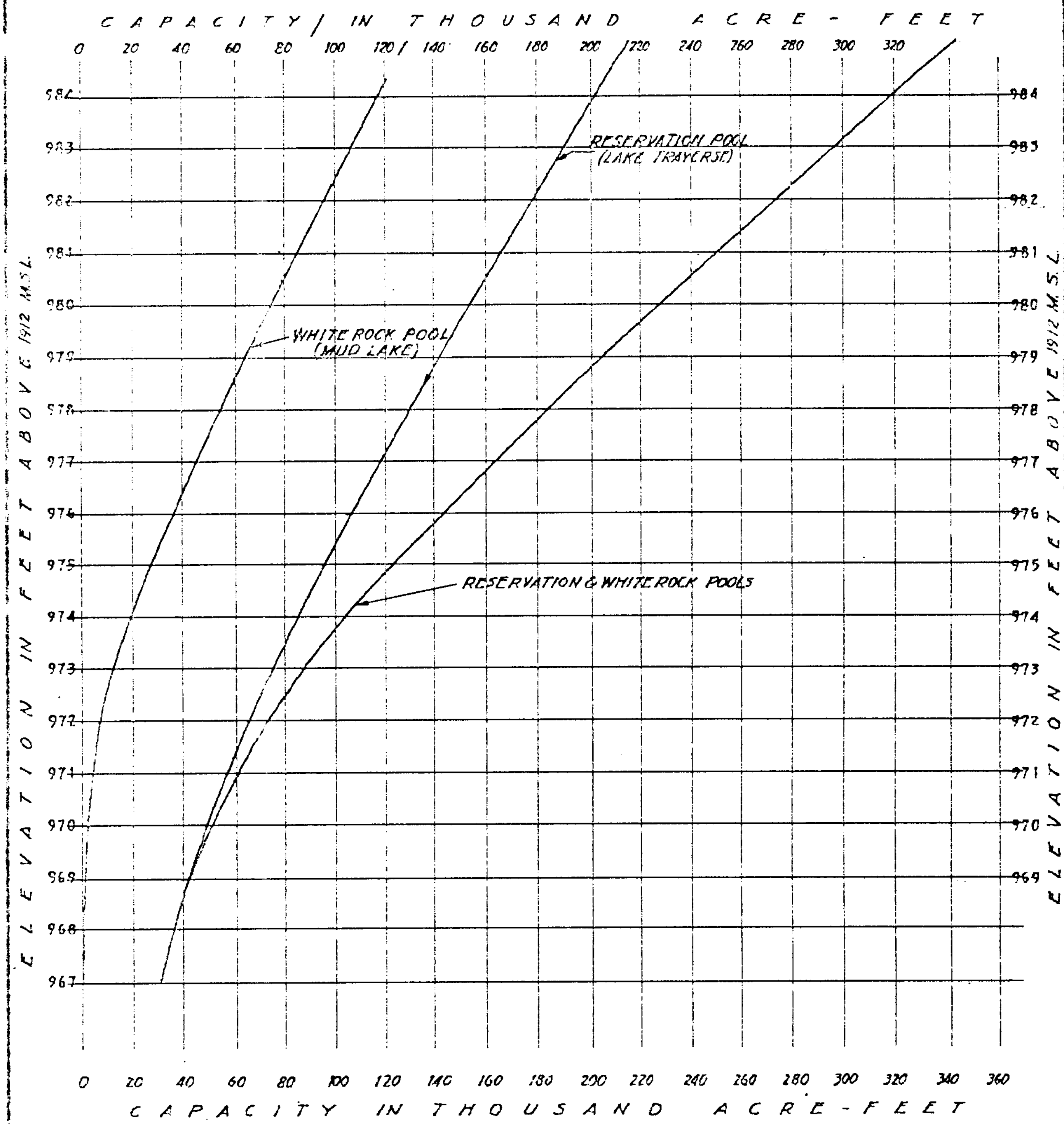
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA
Dwg. No. R30-R-5/16



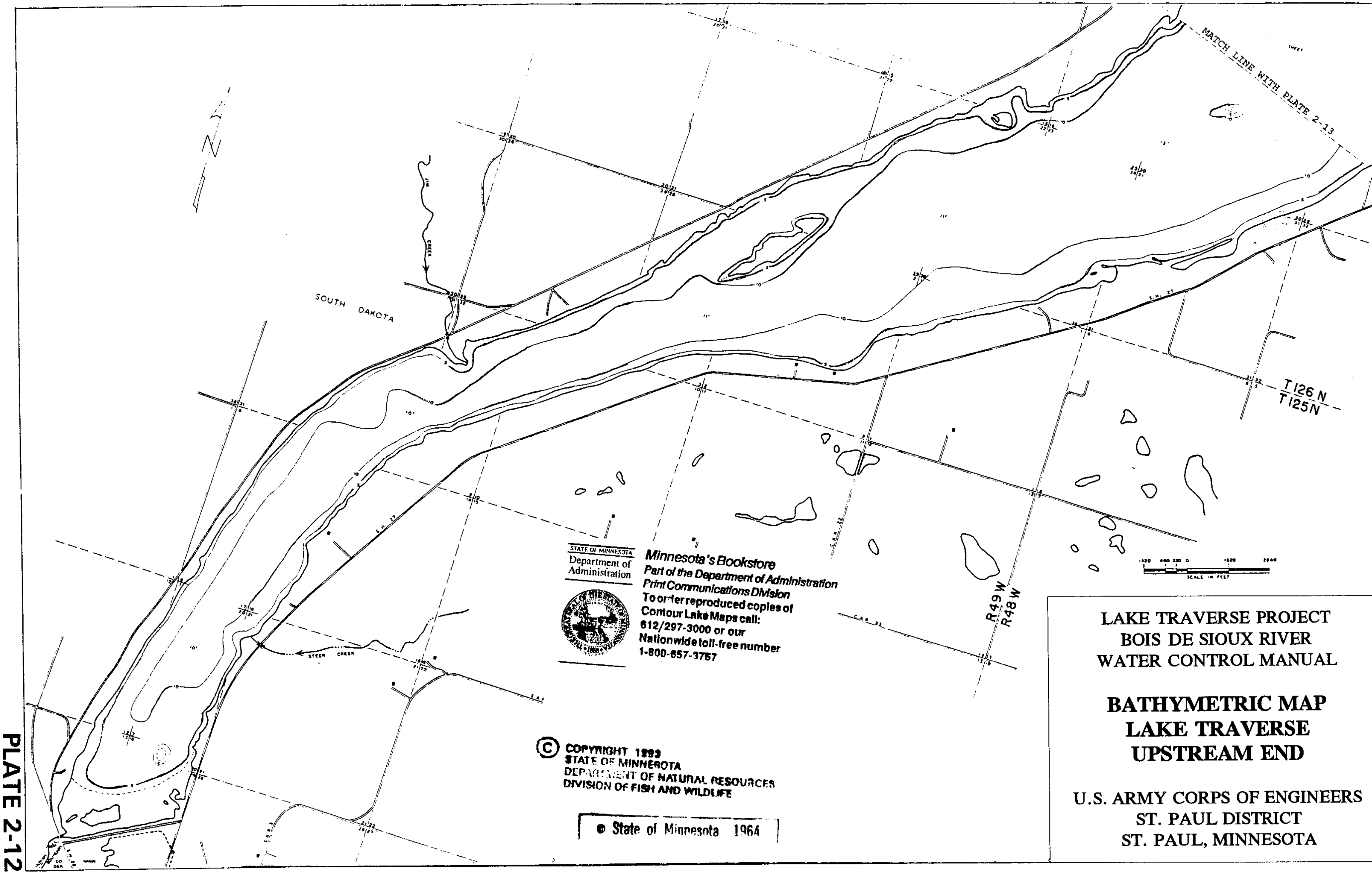
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

ELEVATION - AREA CURVES

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA
Dwg. No. R30-R-5/17



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
ELEVATION-CAPACITY CURVES
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA
Dwg. No. R30-R-5/18

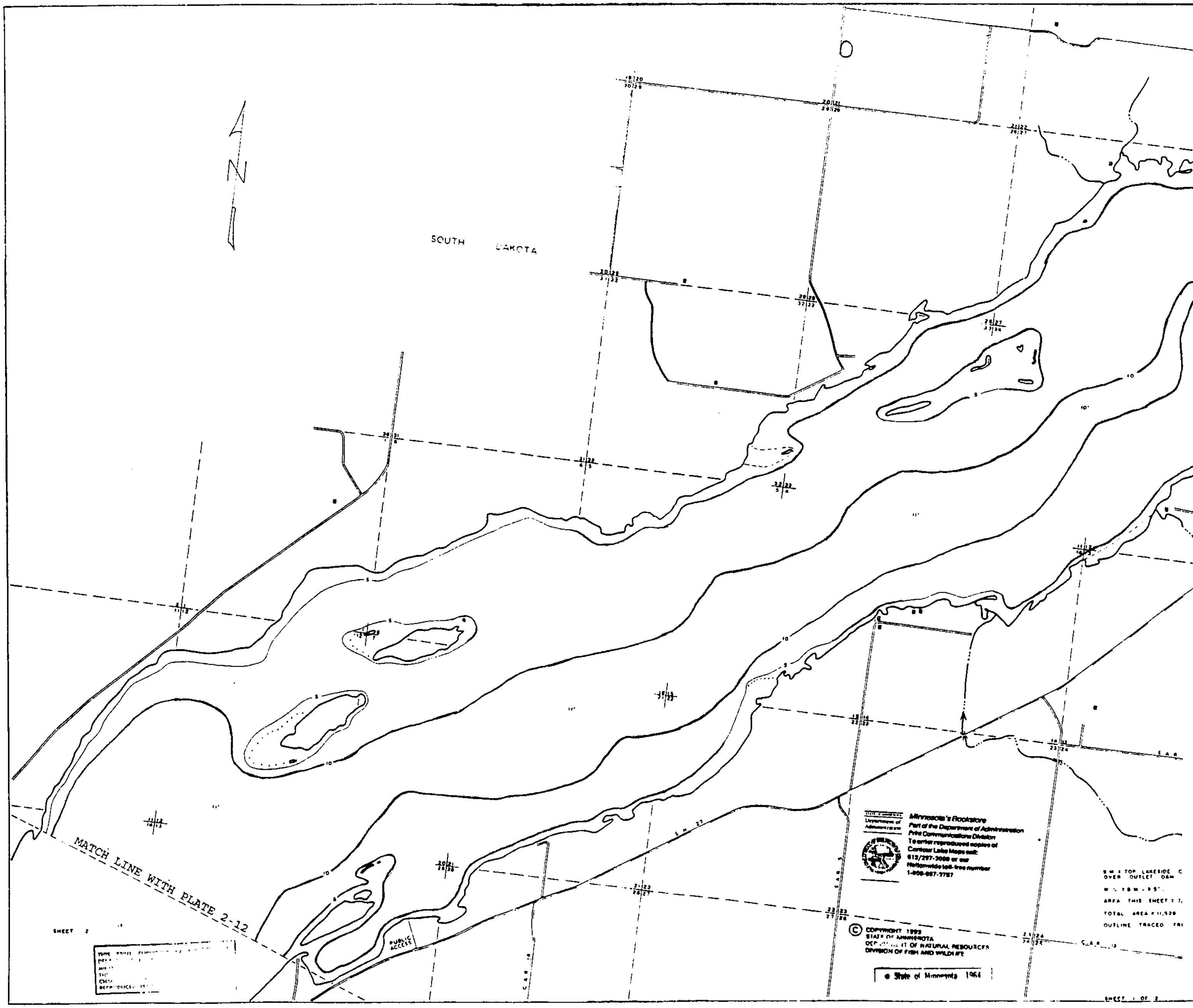


LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

BATHYMETRIC MAP
LAKE TRAVERSE
UPSTREAM END

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

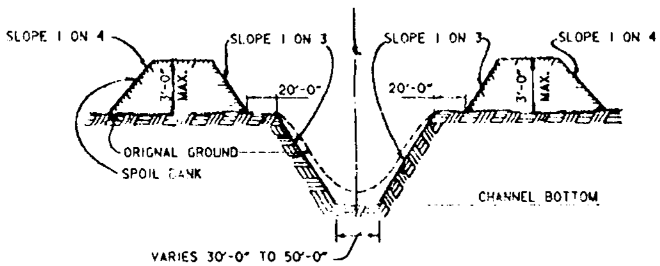
PLATE 2-12



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

BATHYMETRIC MAP
LAKE TRAVERSE
DOWNSTREAM END

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



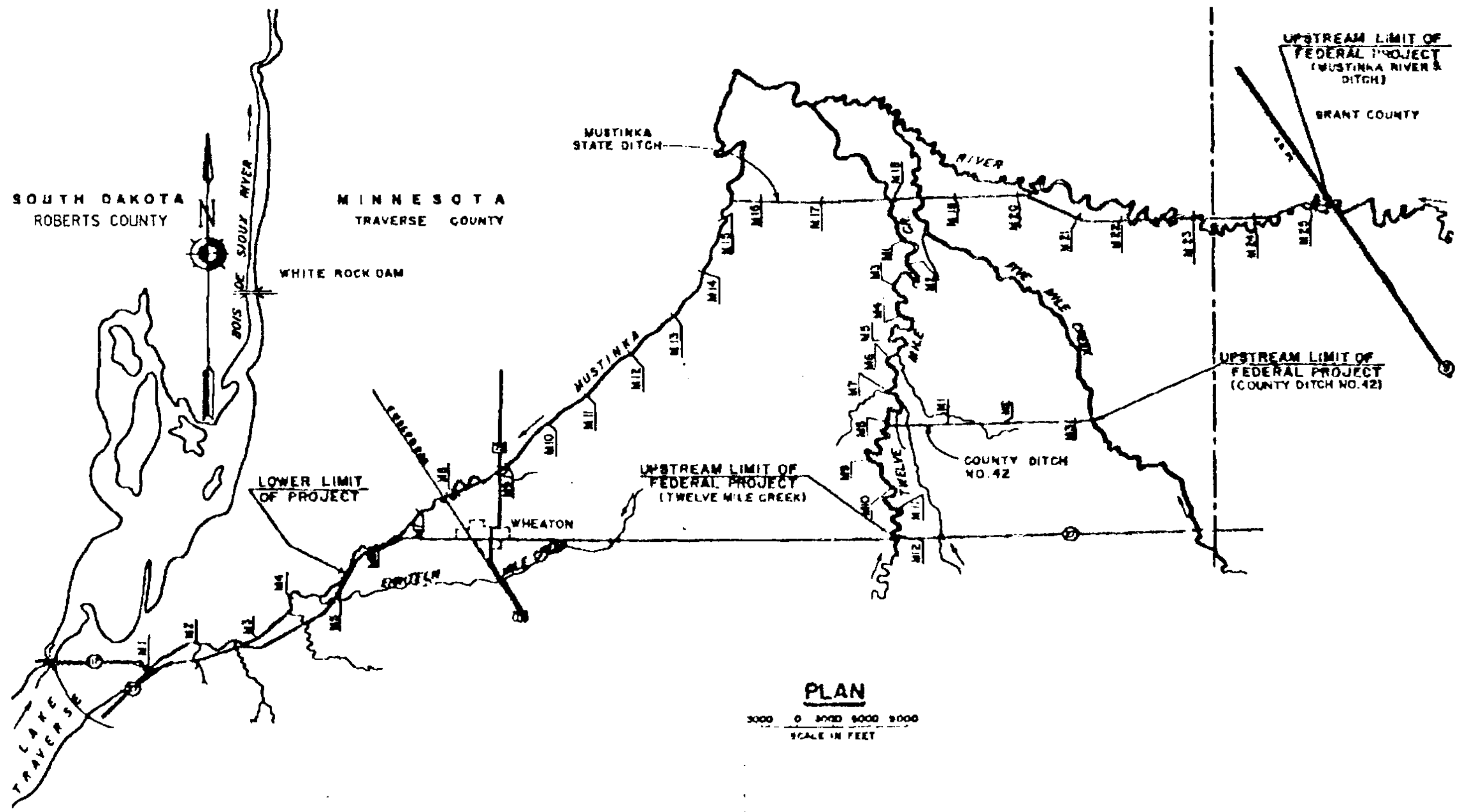
TYPICAL SECTION
(MUSTINKA RIVER)

SCALE IN FEET

LENGTH
MUSTINKA RIVER AND DITCH - 20.6 MILES
TWELVE MILE CREEK - 12.2 MILES
COUNTY DITCH NO. 42 - 3.3 MILES

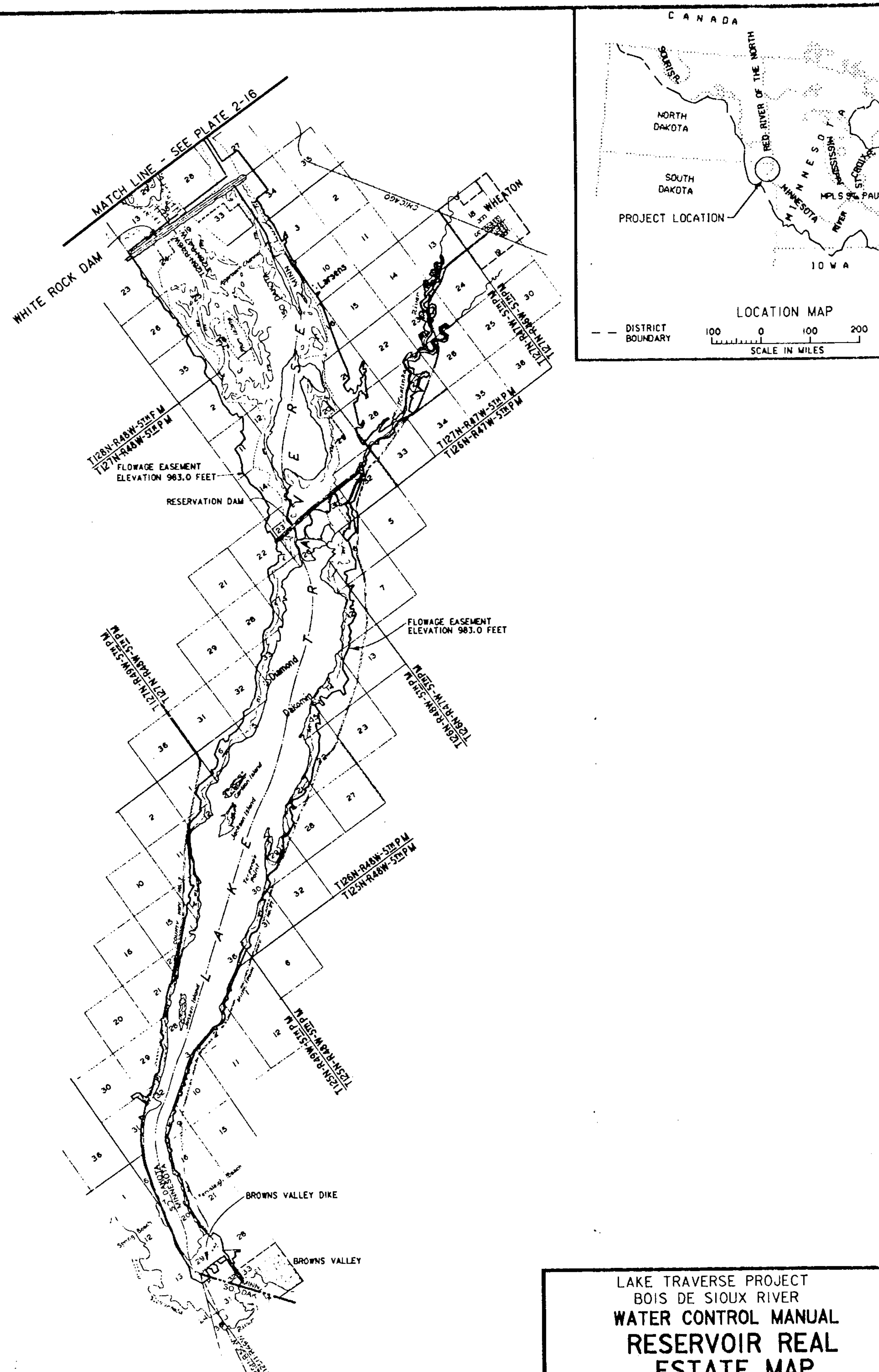
CHANNEL WIDTHS
MUSTINKA RIVER AND DITCH - 30 TO 50 FOOT BOTTOM
TWELVE MILE CREEK - NATURAL
COUONTY DITCH NO. 42 - 10 FOOT BOTTOM.

DESIGN CAPACITY
MUSTINKA RIVER - 830 TO 2140 C.F.S.
TWELVE MILE CREEK - 1420 TO 1615 C.F.S.
COUNTY DITCH NO. 42 - 385 TO 400 C.F.S.
PROVIDING FOR FLOODS OF 10 YEAR FREQUENCY WITH
MINIMUM OF 1 FOOT FREEBOARD AT CONTROLLING SECTIONS.
M3 - MILES ABOVE MOUTH OF RIVERS



PLAN
SCALE IN FEET

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
MUSTINKA RIVER CHANNEL PROJECT
GENERAL PLAN AND
TYPICAL CROSS SECTION
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA
Dwg. No. R30-R-5/19

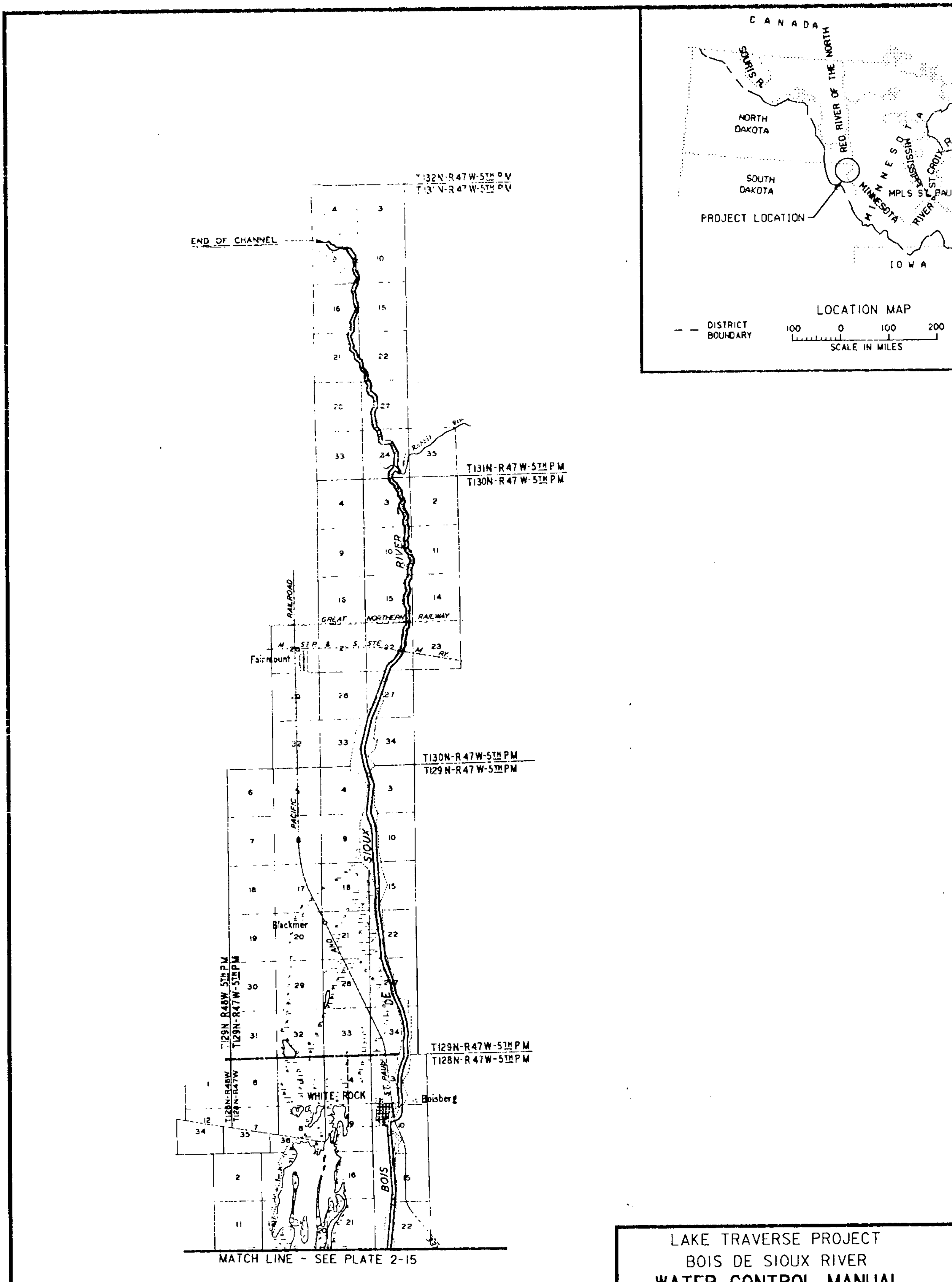


LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

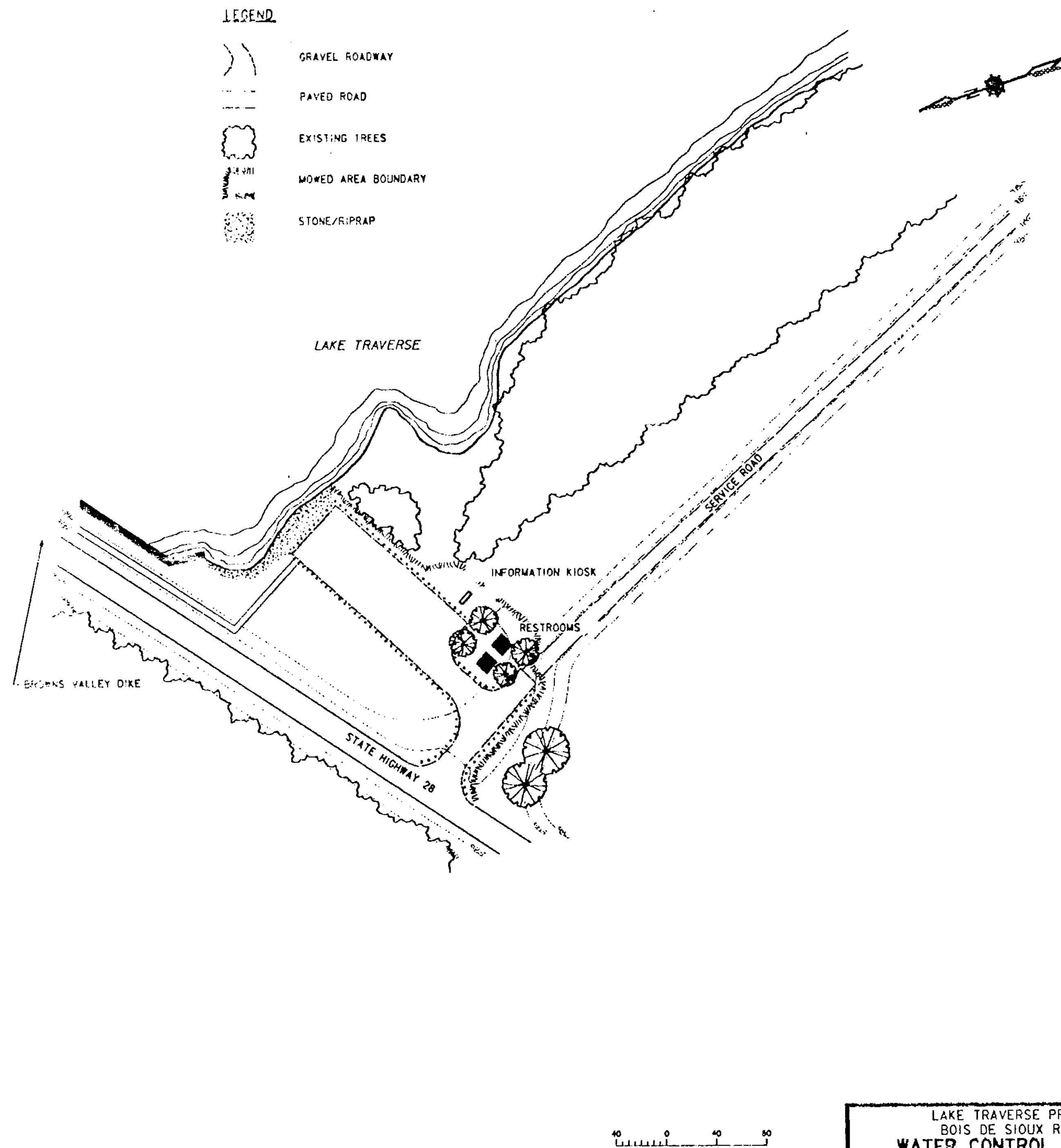
RESERVOIR REAL ESTATE MAP

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

PLATE 2-15

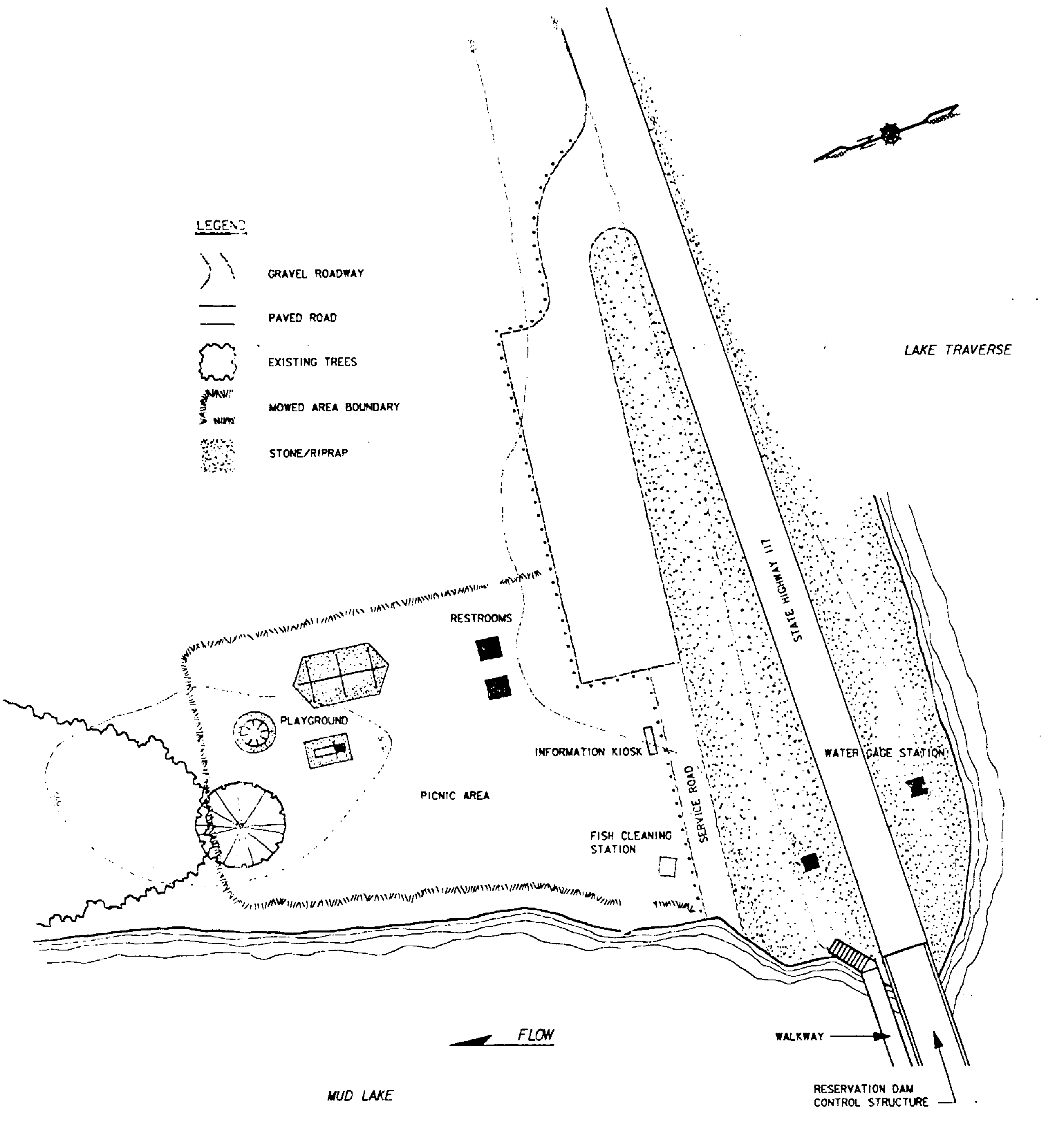


LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
BOIS DE SIOUX RIVER CHANNEL
REAL ESTATE MAP
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
BROWNS VALLEY DIKE
PUBLIC USE SITE
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA
Dwg. No. R30-R-5/22

PLATE 2-17



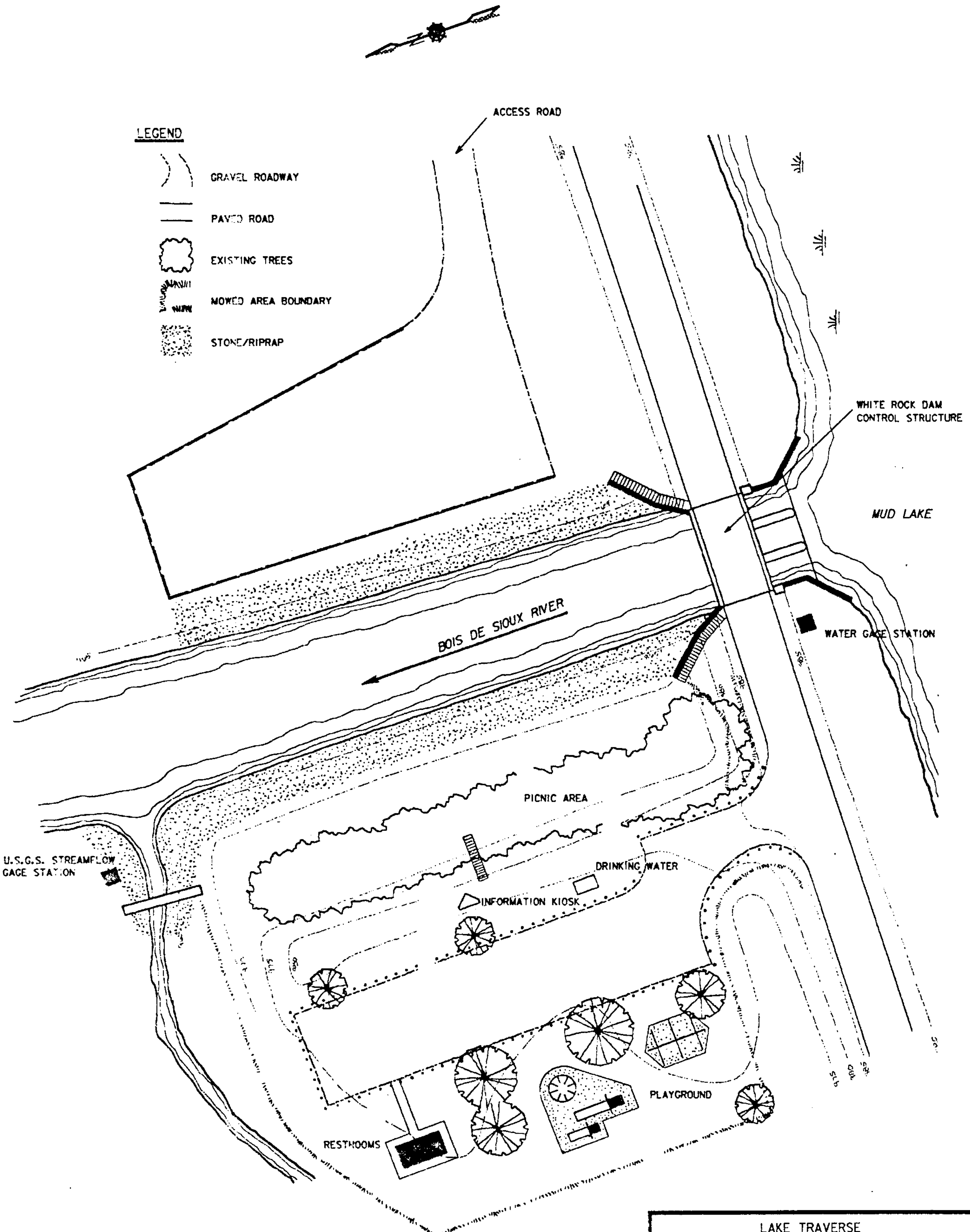
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER

WATER CONTROL MANUAL
RESERVATION DAM

PUBLIC USE SITE

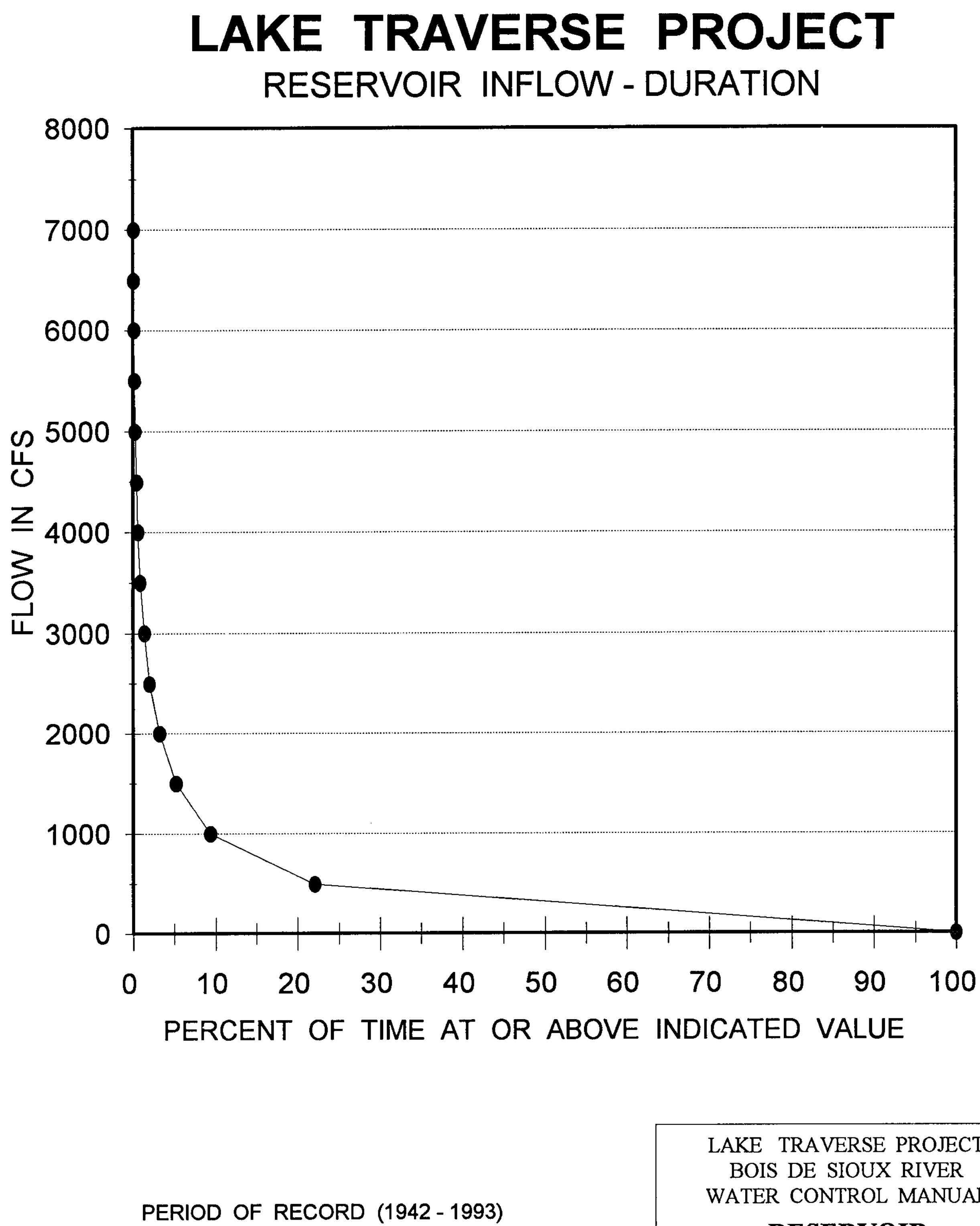
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

PLATE 2-18



LAKE TRAVERSE
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
WHITE ROCK DAM
PUBLIC USE SITE
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

PLATE 2-19



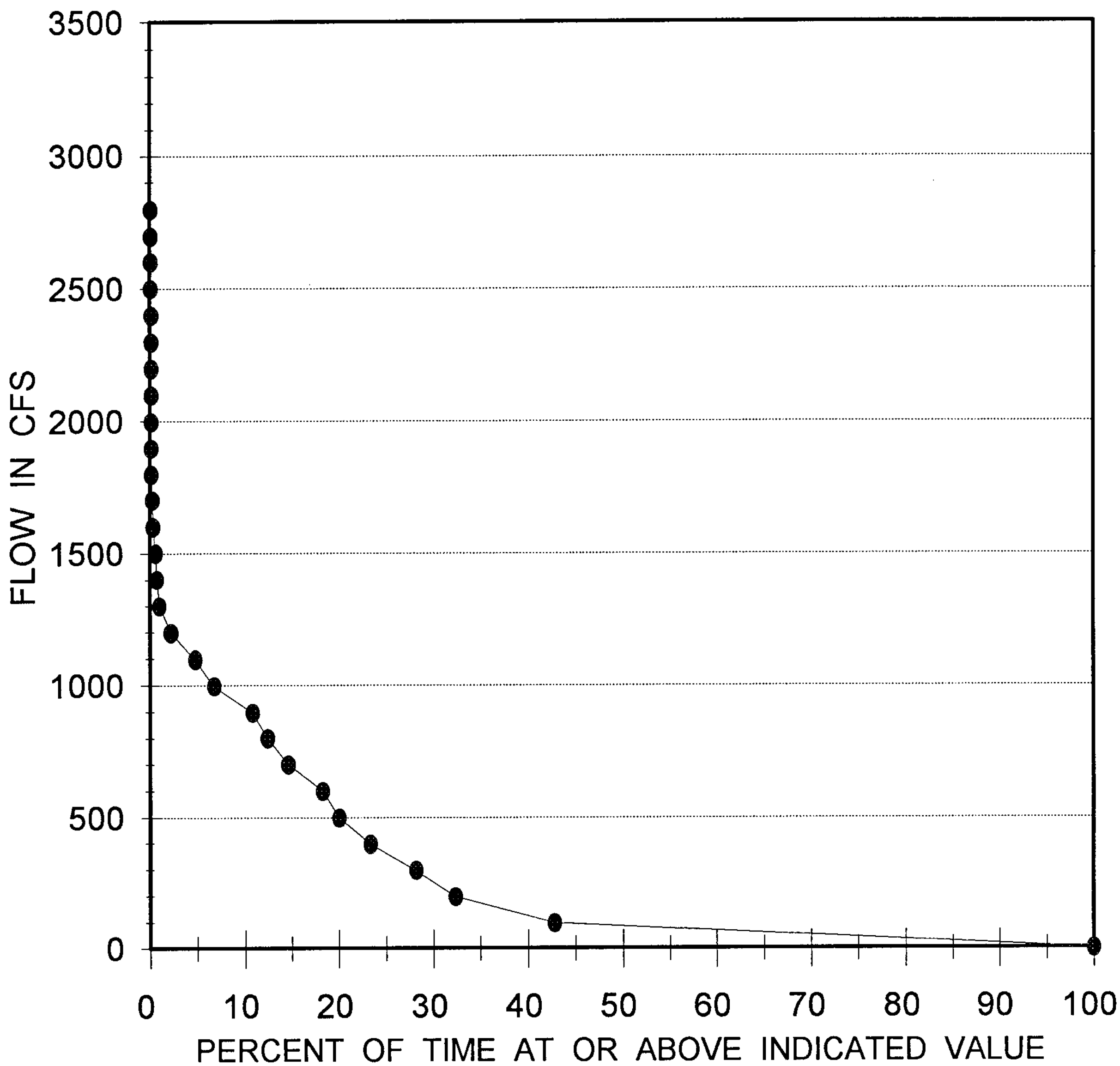
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

RESERVOIR INFLOW - DURATION (ANNUAL)

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

RESERVOIR OUTFLOW - DURATION



PERIOD OF RECORD (1942 - 1993)

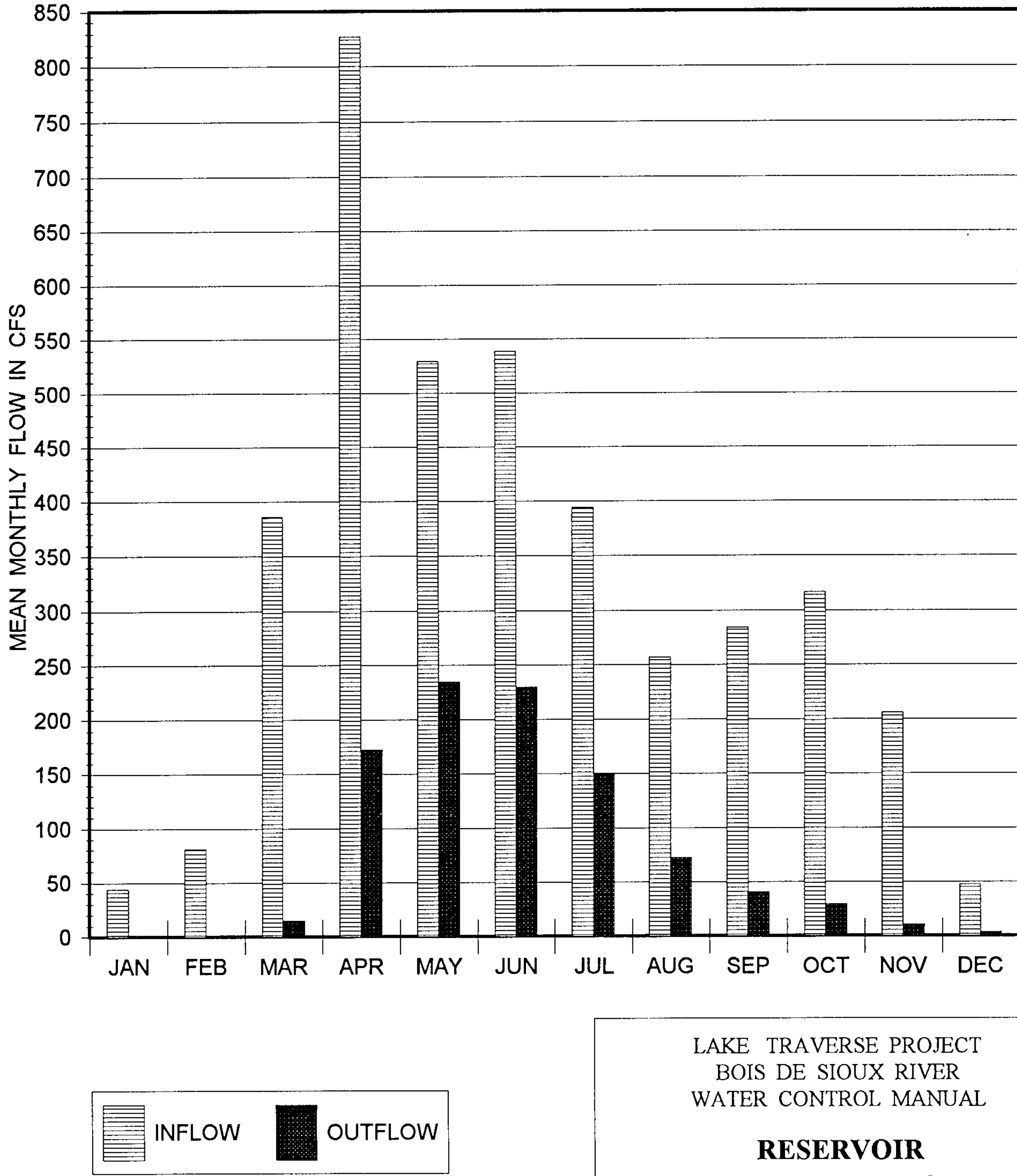
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

RESERVOIR OUTFLOW-DURATION (ANNUAL)

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

RESERVOIR MONTHLY INFLOW - OUTFLOW



PERIOD OF RECORD (1942 - 1993)

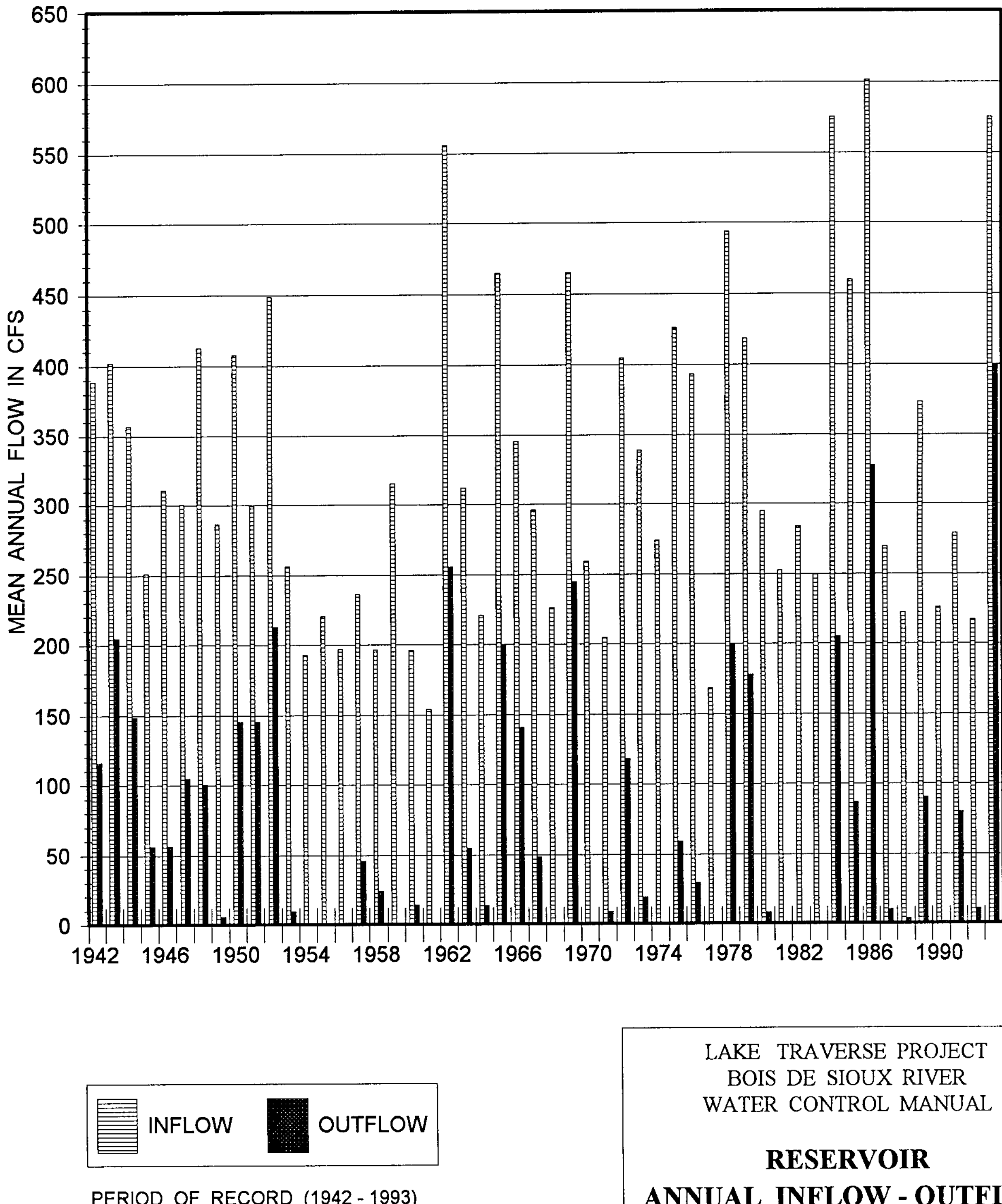
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

RESERVOIR
MONTHLY INFLOW - OUTFLOW

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

RESERVOIR ANNUAL INFLOW - OUTFLOW



PERIOD OF RECORD (1942 - 1993)

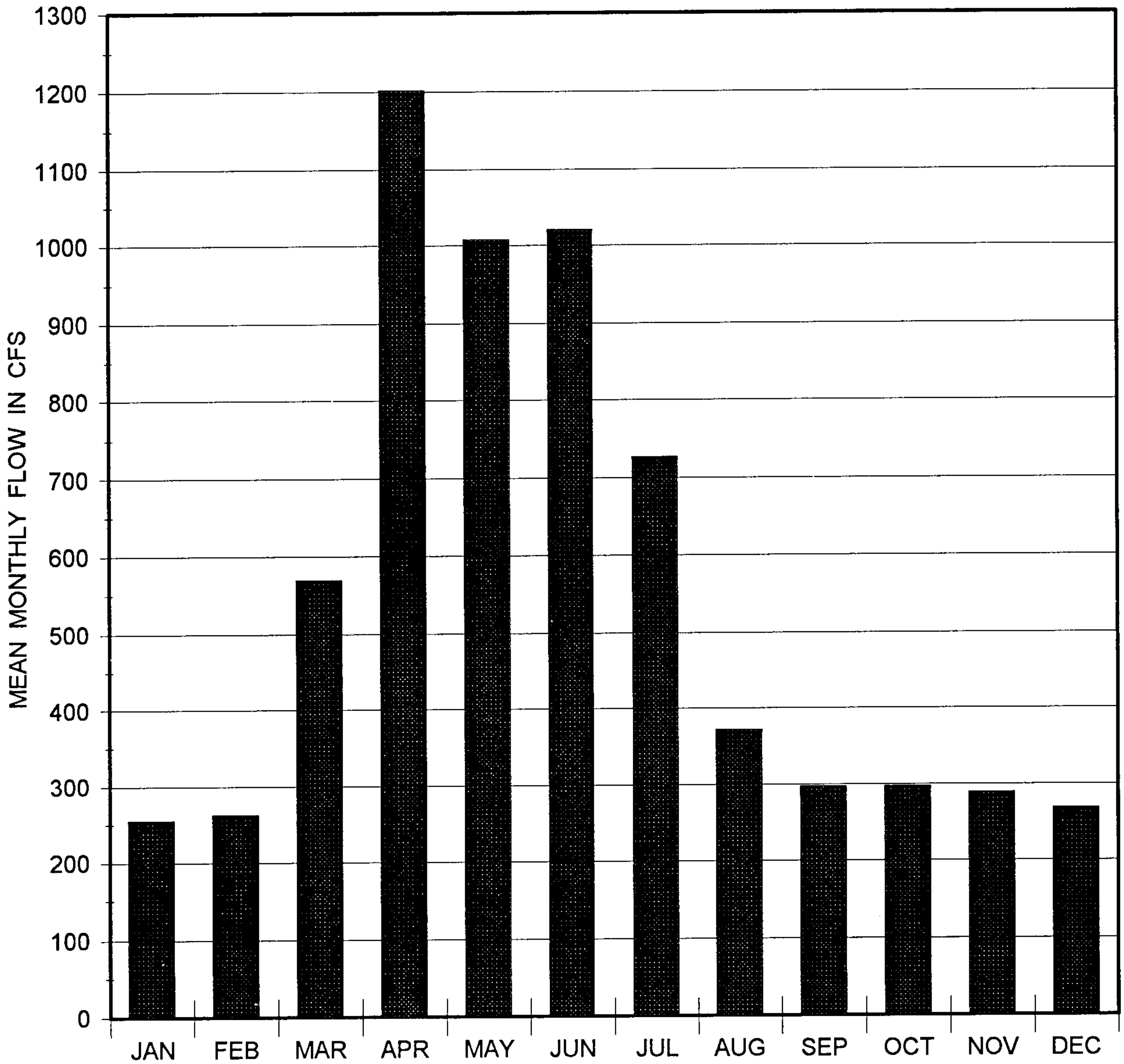
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

RESERVOIR
ANNUAL INFLOW - OUTFLOW

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

RED RIVER OF THE NORTH AT WAHPETON, N.D.

MONTHLY STREAMFLOW DISTRIBUTION

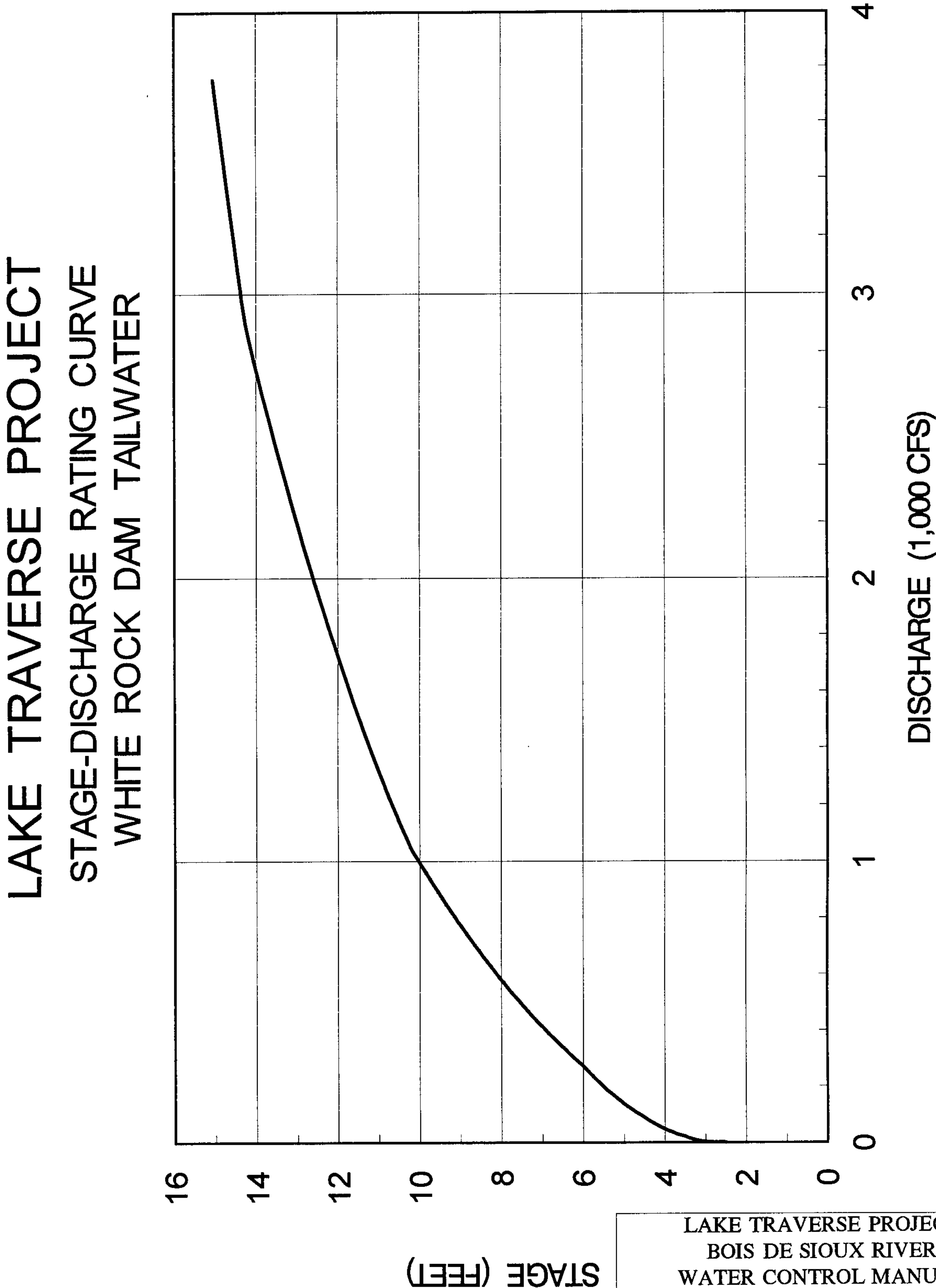


U.S.G.S. GAGE NO. 05051500
PERIOD OF RECORD (1942 - 1991)

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

RED RIVER OF THE NORTH AT WAHPETON, N.D. MONTHLY STREAMFLOW DISTRIBUTION

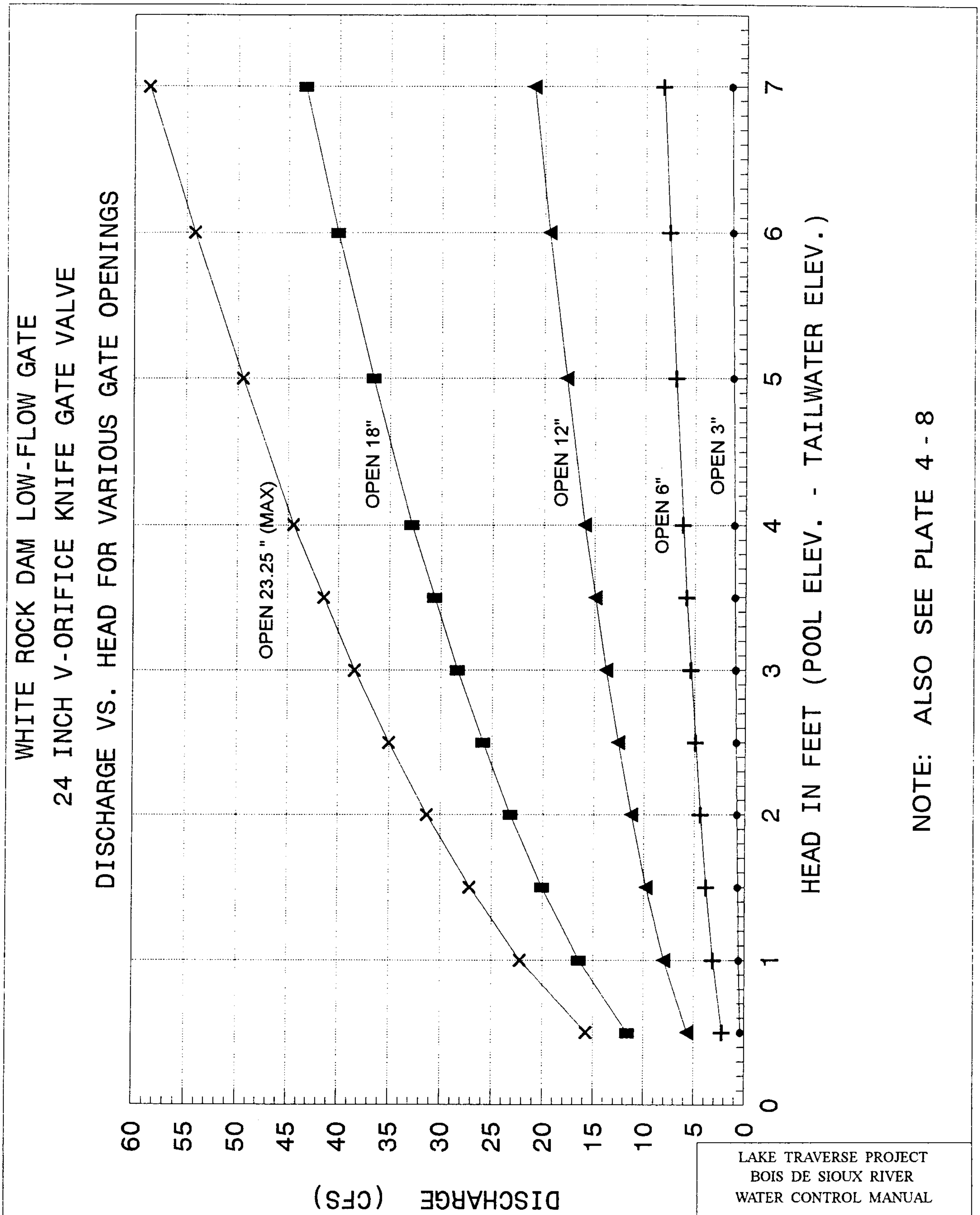
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

STAGE-DISCHARGE
U.S.G.S. GAGE NO. 05050000
300 FEET DOWNSTREAM OF
WHITE ROCK DAM

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

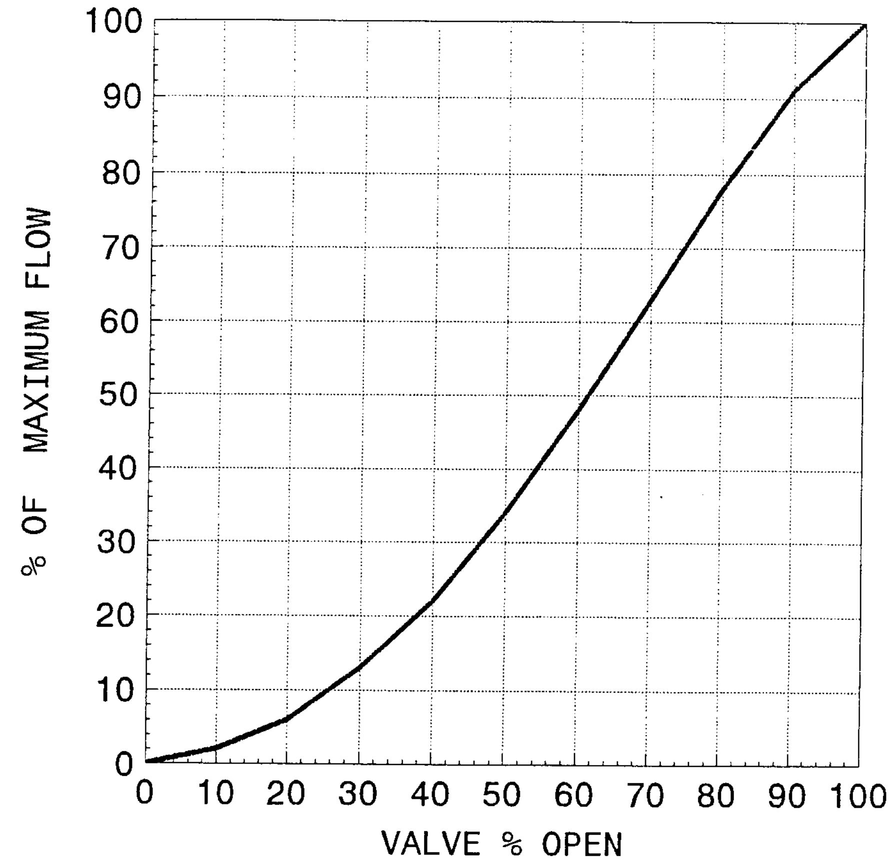


LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

**WHITE ROCK DAM
LOW-FLOW GATE
DISCHARGE VS. HEAD**

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

FLOW CHARACTERISTICS FOR DEZURIK SERIES L V-ORIFICE VALVES



INSTRUCTIONS FOR THE USE OF THIS CHART WITH AN EXAMPLE:

1. CALCULATE % VALVE OPEN : % VALVE OPEN = (100)(VALVE OPENING IN INCHES)/23.25
   NOTE THAT THE MAXIMUM OPENING FOR A 24-INCH V-ORIFICE VALVE IS 23.25 INCHES
   EXAMPLE: IF THE VALVE IS OPEN 3 INCHES, VALVE % OPEN = 100(3)/23.25 = 12.9

2. FIND "% OF MAXIMUM FLOW" FOR "VALVE % OPEN" FROM THE CHART ABOVE
   EXAMPLE: FOR VALVE % OPEN = 12.9, % OF MAXIMIUM FLOW = 2.5 FROM THE CHART

3. CALCULATE Cv1 : Cv1 = [(% OF MAXIMUM FLOW)/100](Cv FOR VALVE 100% OPEN)
   = [(% OF MAXIMUM FLOW)/100](15100)
   NOTE THAT FOR A 24-INCH V-ORIFICE VALVE WHICH IS 100% OPEN, Cv = 15100
   EXAMPLE: Cv1 = (2.5/100)15100 = 378

4. CONVERT HEAD TO POUNDS PER SQUARE INCH (PSI) ON THE GATE: PSI = (HEAD IN FEET)(0.4335)
   EXAMPLE: 4 FEET OF HEAD = 4(0.4335) PSI = 1.73 PSI

5. CALCULATE FLOW THROUGH THE VALVE IN GALLONS PER MINUTE (GPM) : GPM = (Cv1)($\sqrt{\text{PSI}}$)
   EXAMPLE: GPM = (378)($\sqrt{1.73}$) = 498 GPM

6. CONVERT GPM TO CUBIC FEET PER SECOND (CFS) :
   FLOW IN CFS = (FLOW IN GPM)/(448.831)
   EXAMPLE: CFS = 498/448.831 = 1.11 CFS

REFERENCE: DEZURIK CORPORATION, SARTELL, MINNESOTA
(612) 259-2000

NOTE: ALSO SEE PLATE 4 - 7

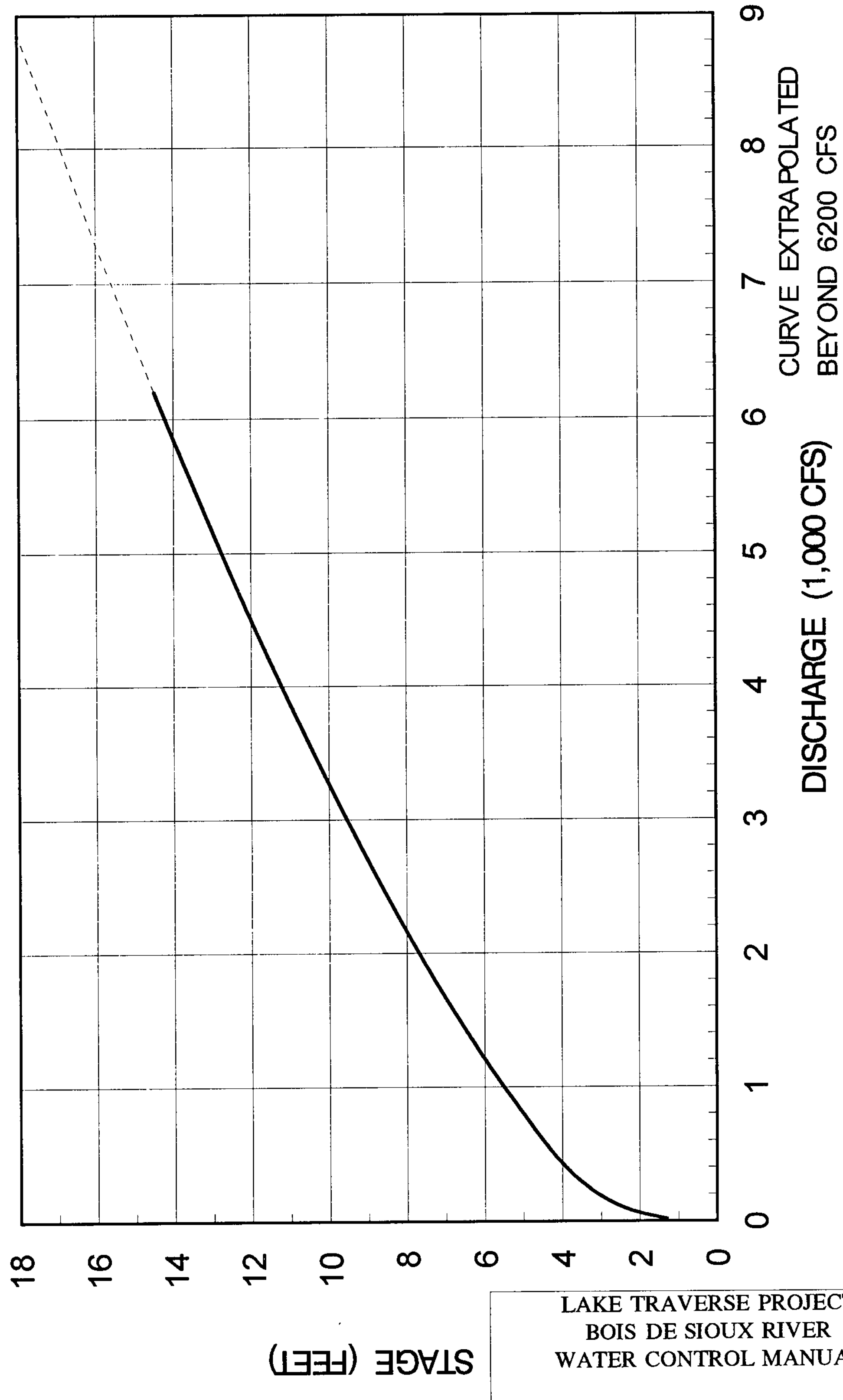
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

WHITE ROCK DAM
LOW-FLOW GATE
FLOW COMPUTATION

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

STAGE-DISCHARGE RATING CURVE
RED RIVER OF THE NORTH AT WAHPETON, ND



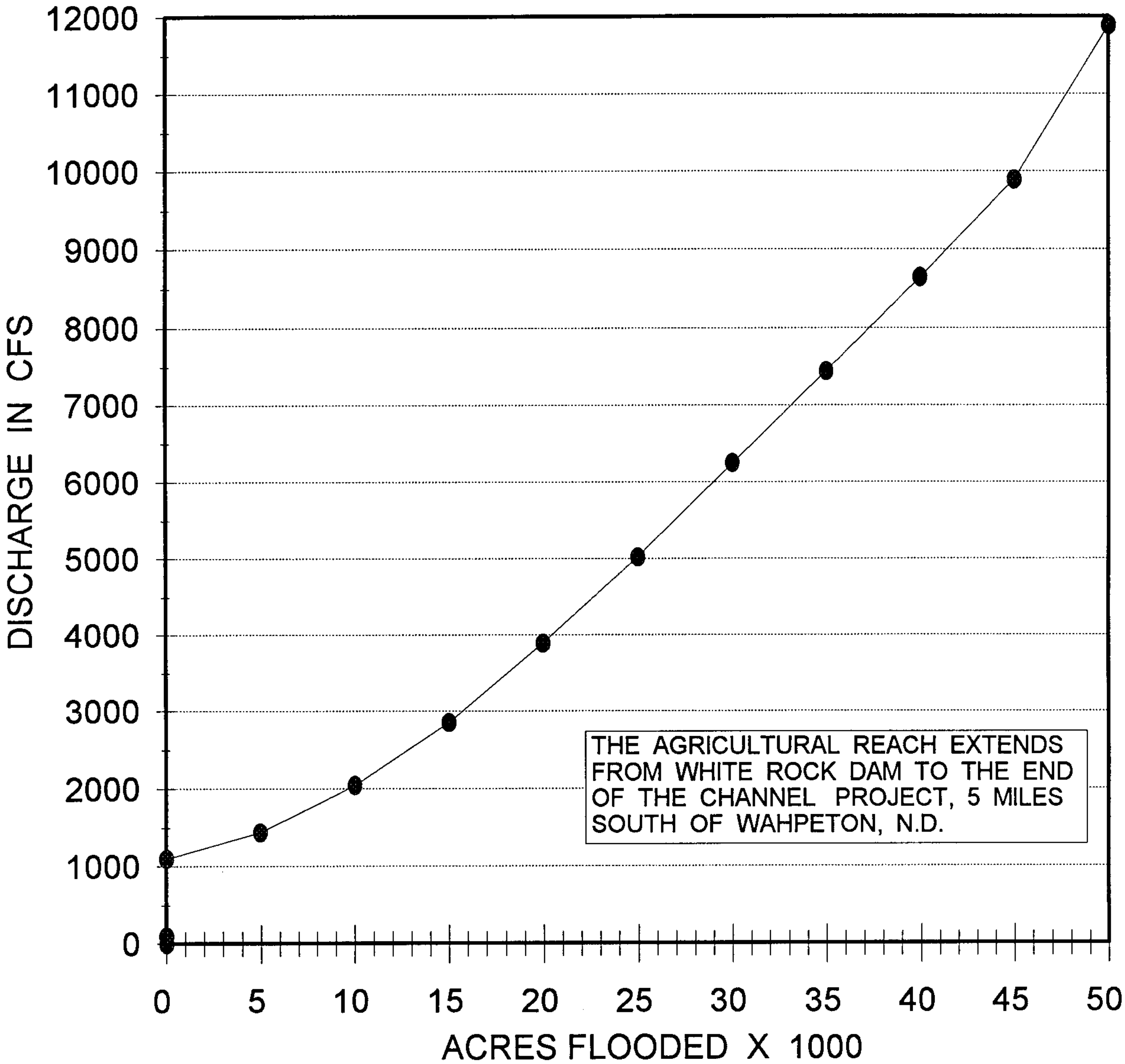
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

STAGE-DISCHARGE
U.S.G.S. GAGE NO. 05051500
RED RIVER OF THE NORTH
AT WAHPETON, ND

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

AGRICULTURAL REACH
DISCHARGE - AREA FLOODED



AGRICULTURAL ACRES FLOODED ARE REFERENCED TO TAILWATER DISCHARGE FROM WHITE ROCK DAM U.S.G.S GAGE NO. 05050000

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

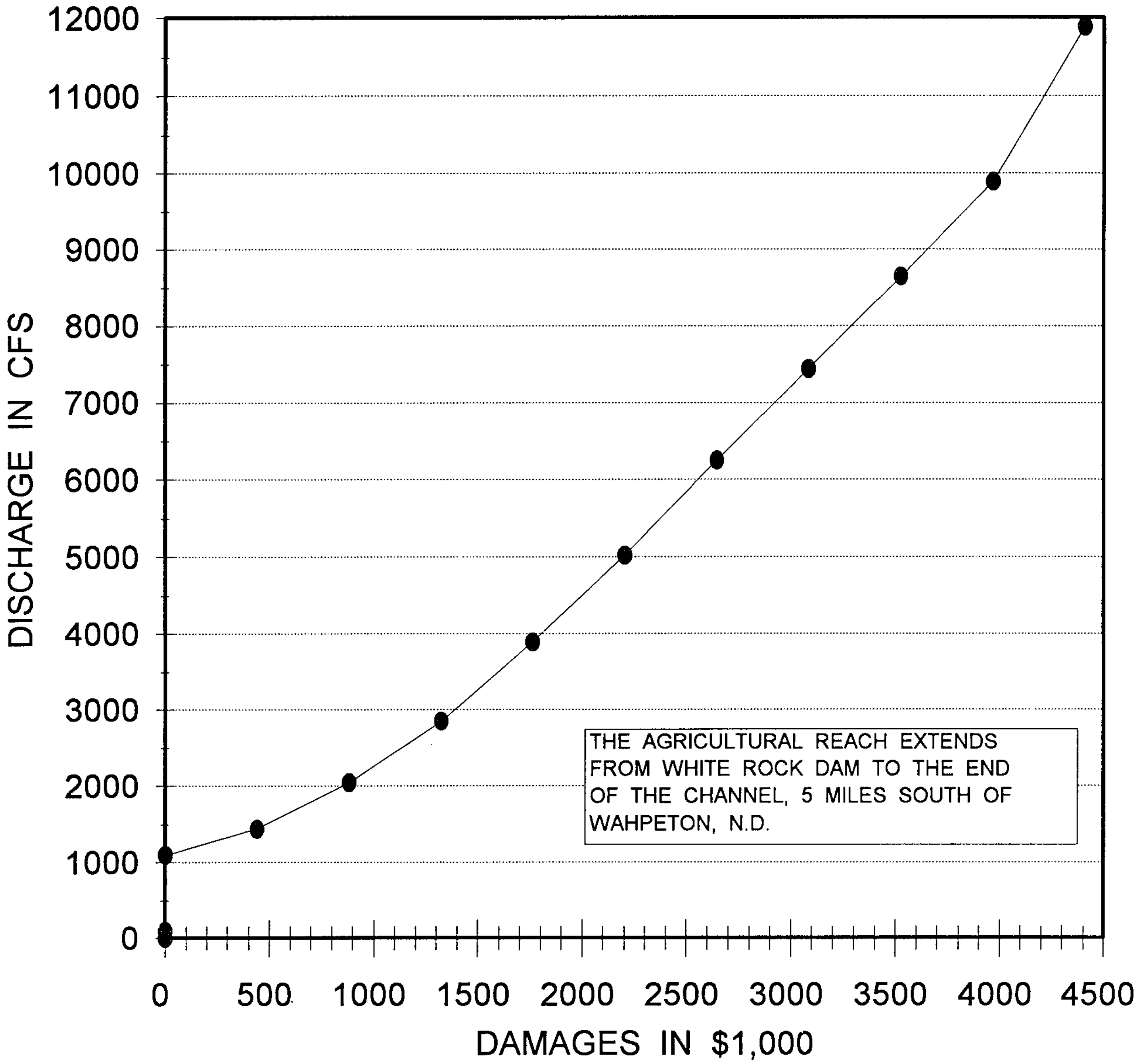
AGRICULTURAL REACH
DISCHARGE - ACRES FLOODED

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

AGRICULTURAL REACH

DISCHARGE - DAMAGE



AGRICULTURAL DAMAGES ARE
REFERENCED TO TAILWATER
DISCHARGE FROM WHITE ROCK DAM
U.S.G.S. GAGE NO. 05050000

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

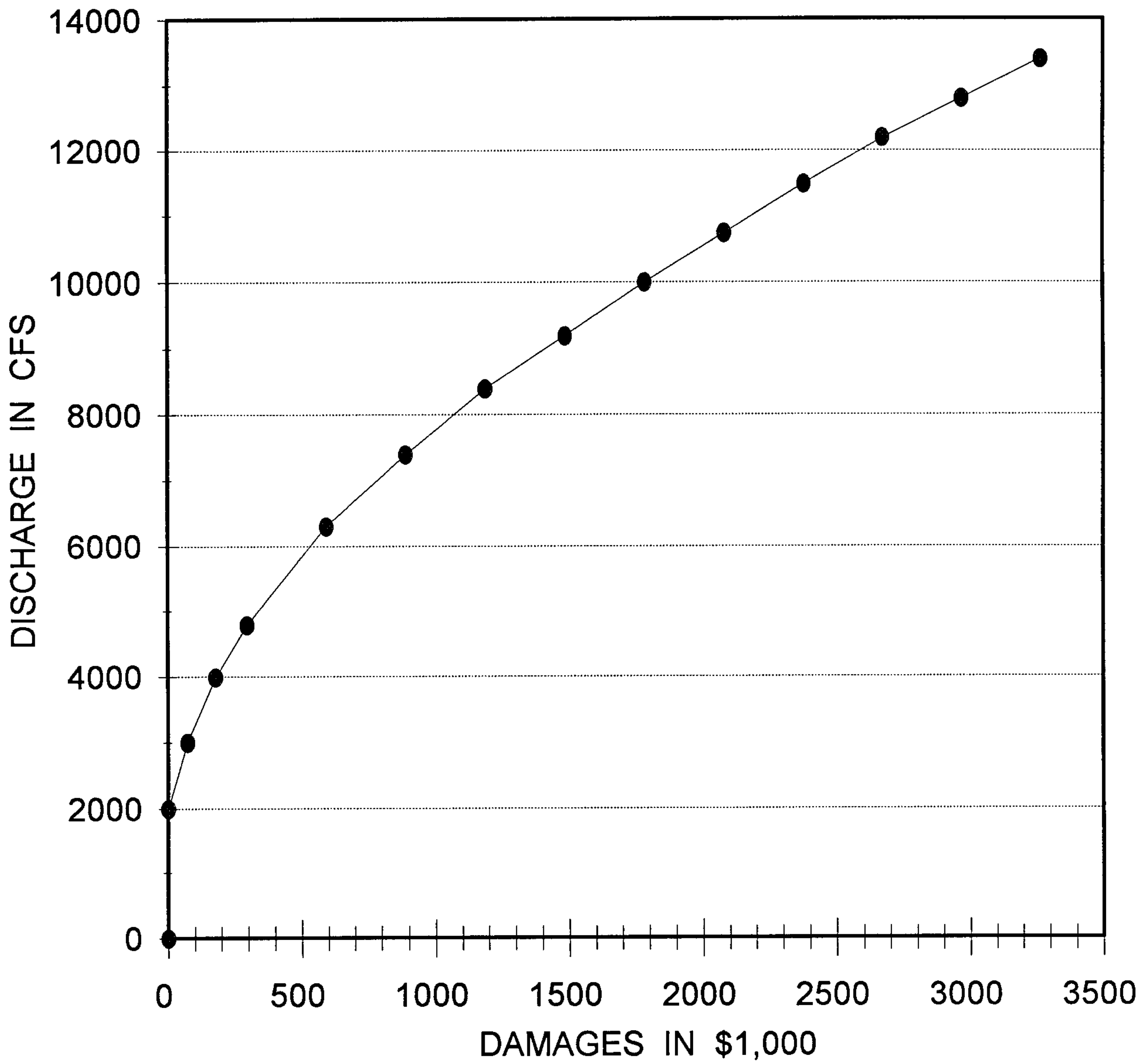
AGRICULTURAL REACH
DISCHARGE - DAMAGE

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

WAHPETON URBAN

DISCHARGE - DAMAGE



WAHPETON URBAN DAMAGES ARE REFERENCED TO THE RED RIVER OF THE NORTH AT WAHPETON, N.D. U.S.G.S. GAGE NO. 05051500

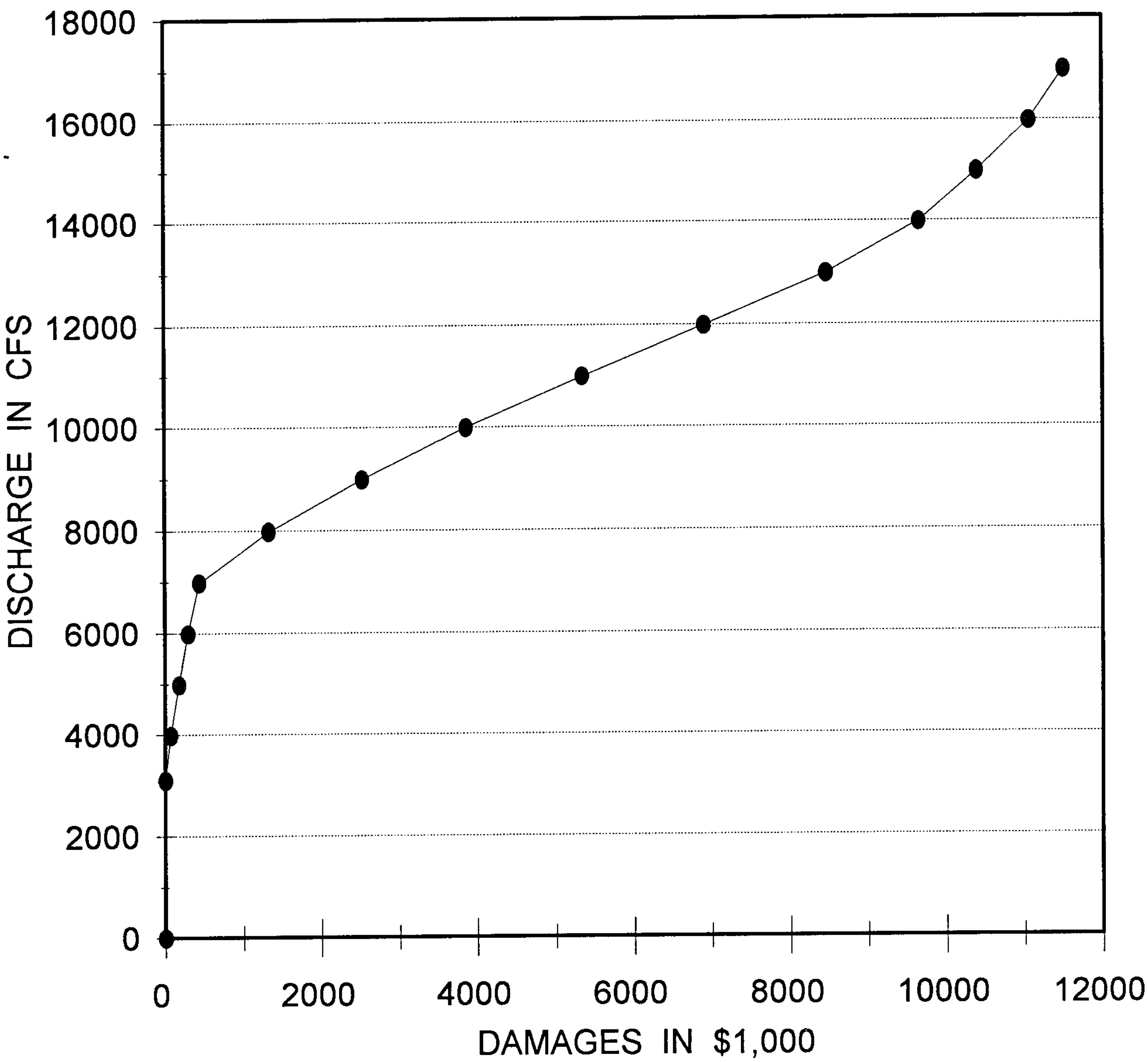
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

WAHPETON URBAN
DISCHARGE - DAMAGE

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

BRECKENRIDGE URBAN
DISCHARGE - DAMAGE



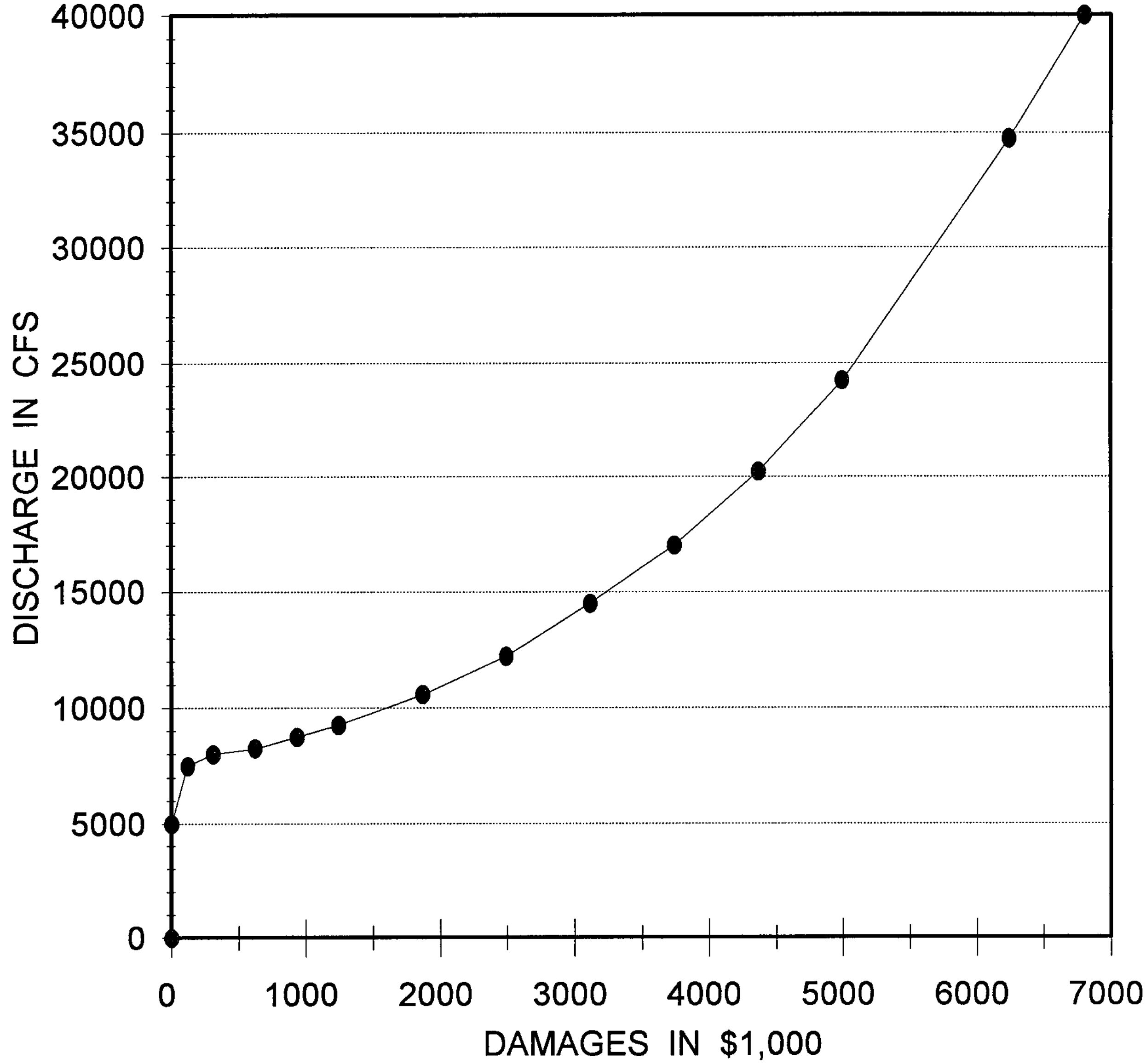
BRECKENRIDGE URBAN DAMAGES ARE REFERENCED TO THE RED RIVER OF THE NORTH AT WAHPETON, N.D. U.S.G.S. GAGE NO. 05051500

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

BRECKENRIDGE URBAN DISCHARGE - DAMAGE

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT
FARGO URBAN
DISCHARGE - DAMAGE



FARGO URBAN DAMAGES ARE REFERENCED TO THE RED RIVER OF THE NORTH AT FARGO, N.D. U.S.G.S. GAGE NO. 05054000

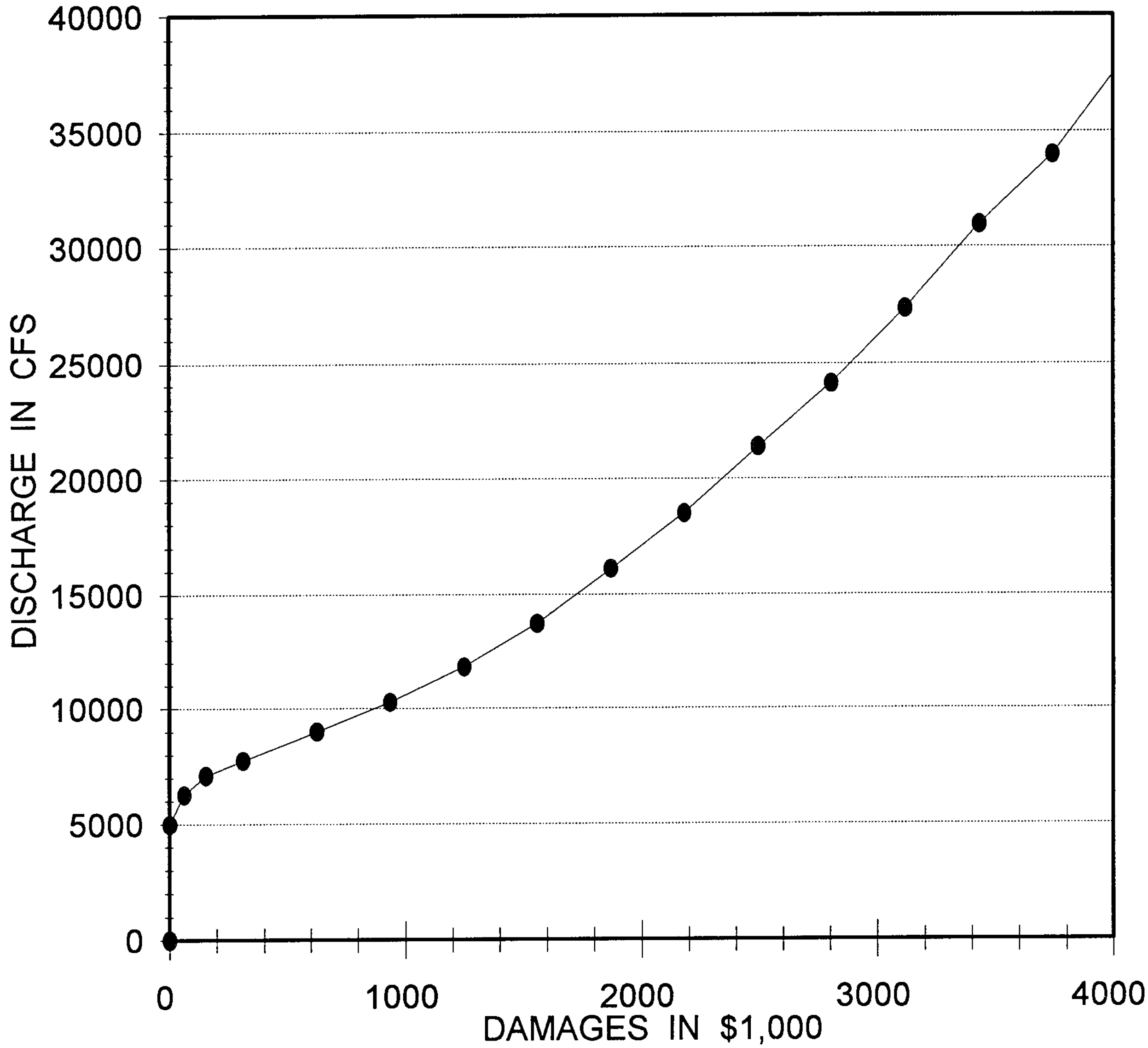
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

FARGO URBAN
DISCHARGE - DAMAGE

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LAKE TRAVERSE PROJECT

MOORHEAD URBAN
DISCHARGE - DAMAGE

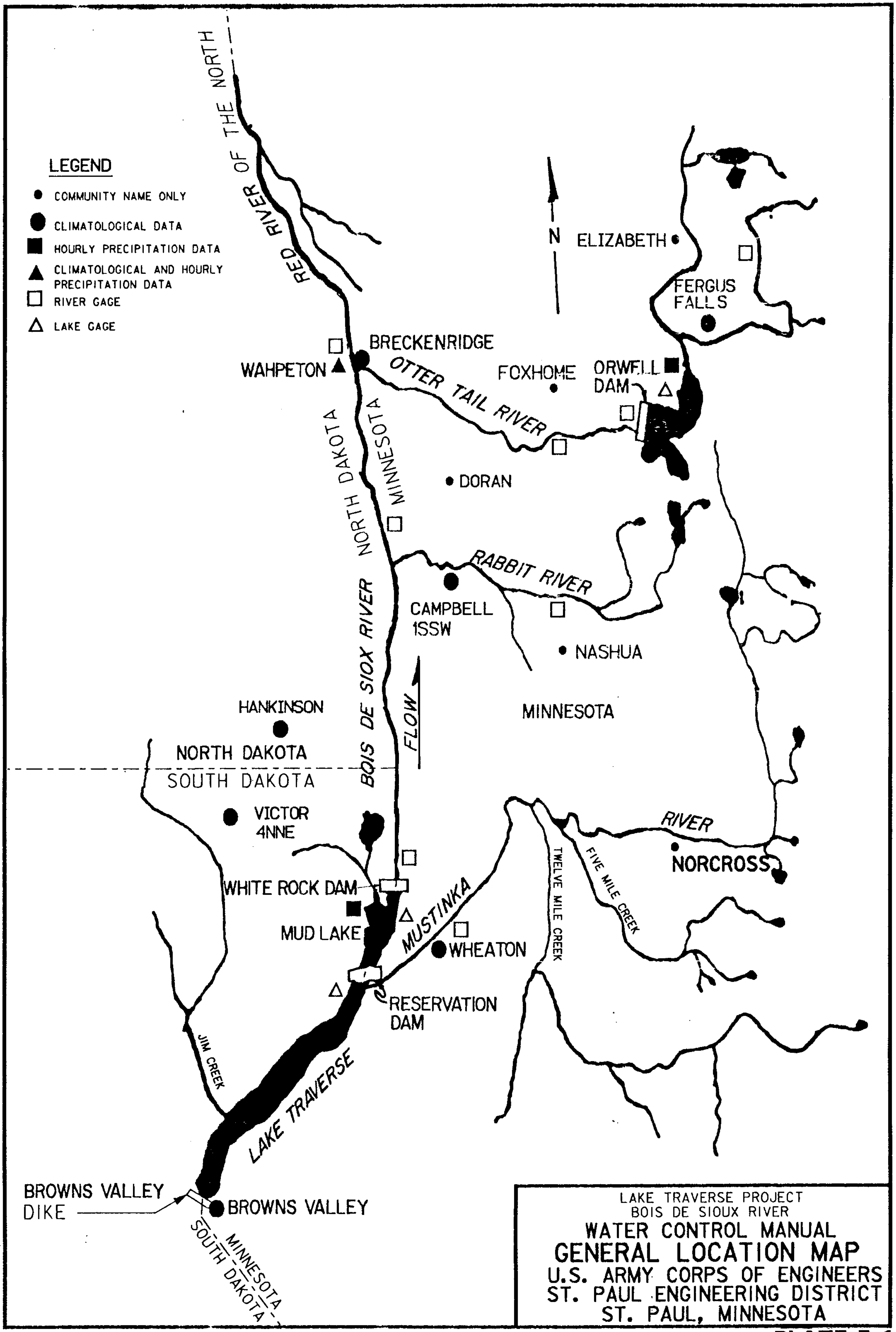


MOORHEAD URBAN DAMAGES ARE REFERENCED TO THE RED RIVER OF THE NORTH AT FARGO, N.D. U.S.G.S GAGE NO. 05054000

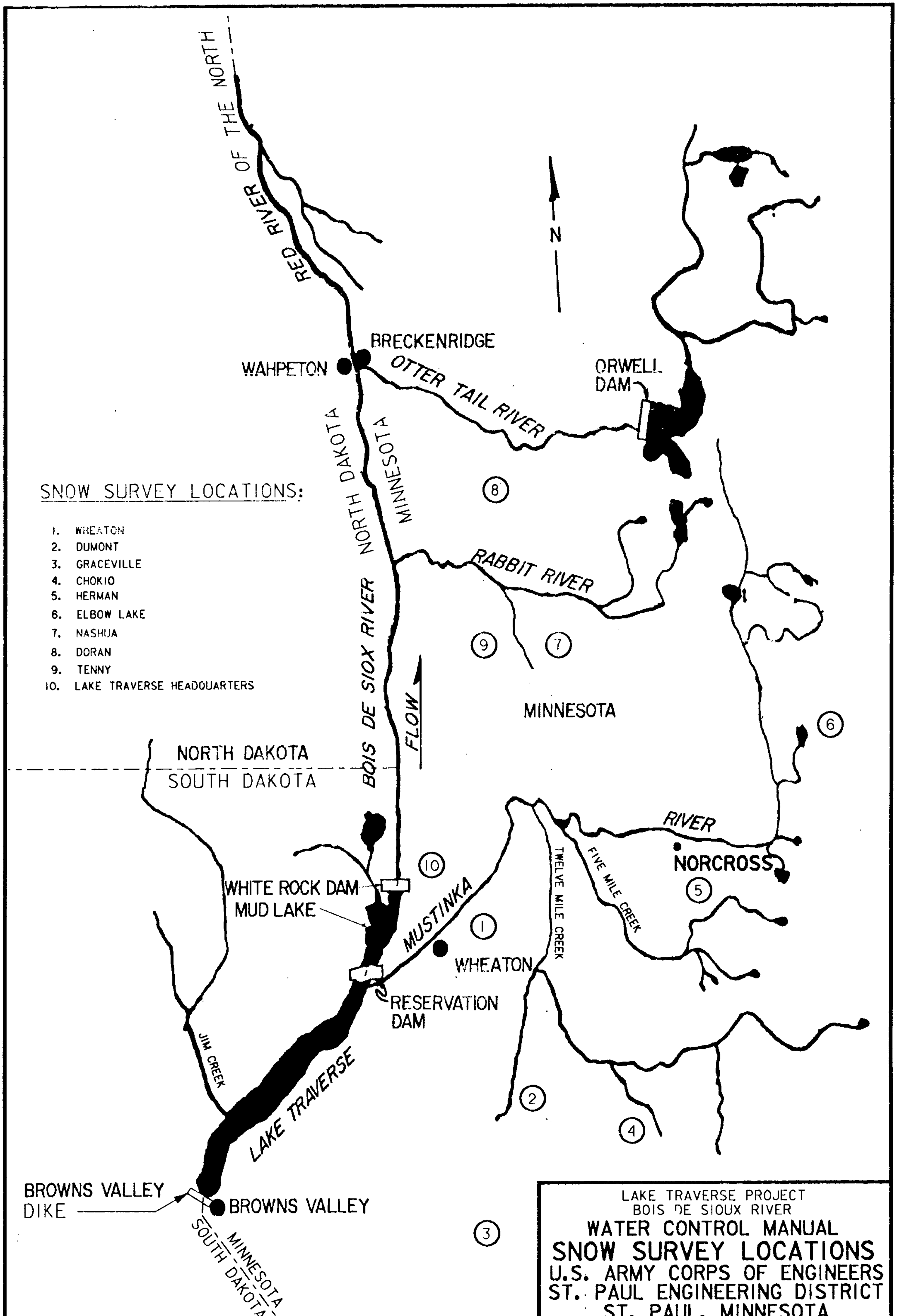
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

MOORHEAD URBAN
DISCHARGE - DAMAGE

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

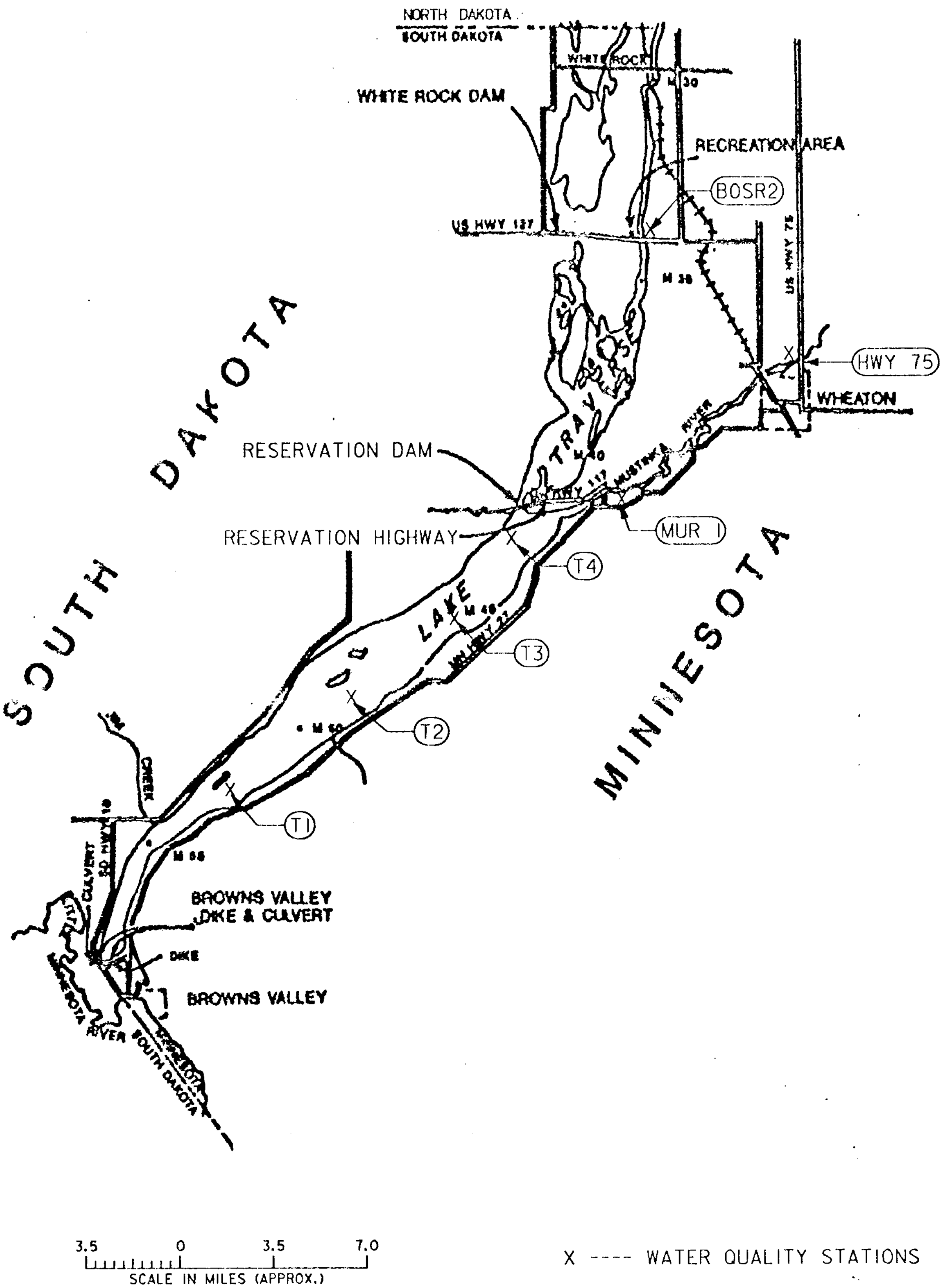


LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
GENERAL LOCATION MAP
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
SNOW SURVEY LOCATIONS
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

PLATE 5-2



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

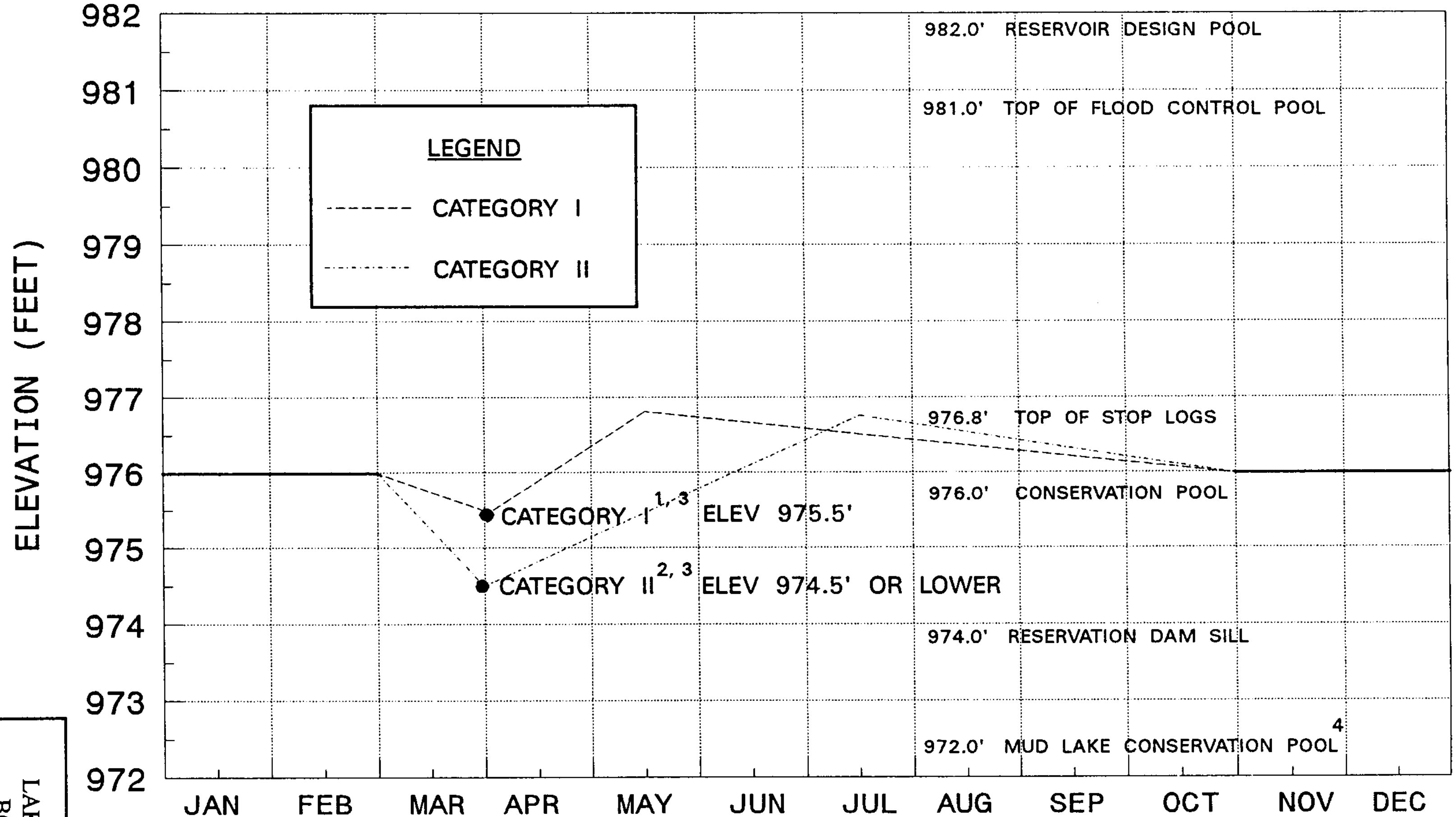
WATER QUALITY STATIONS

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

Dwg. No. R30-R-5/26

PLATE 5-3

LAKE TRAVERSE PROJECT REGULATION SCHEDULE



NOTES :

1. A CATEGORY I DRAWDOWN IS DONE IF THE LATE FEBRUARY BASIN-AVERAGE SNOW WATER CONTENT IS LESS THAN 3 INCHES. RESERVATION POOL IS DRAWN DOWN TO ELEVATION 975.5 BY 31 MARCH. TARGET STAGE AT WAHPETON IS 10.0 FEET.

2. A CATEGORY II DRAWDOWN IS DONE IF THE LATE FEBRUARY BASIN-AVERAGE SNOW WATER CONTENT IS 3 OR MORE INCHES. RESERVATION POOL IS DRAWN DOWN TO ELEVATION 974.5 OR LOWER BY 31 MARCH. TARGET STAGE AT WAHPETON IS 12.0 FEET.

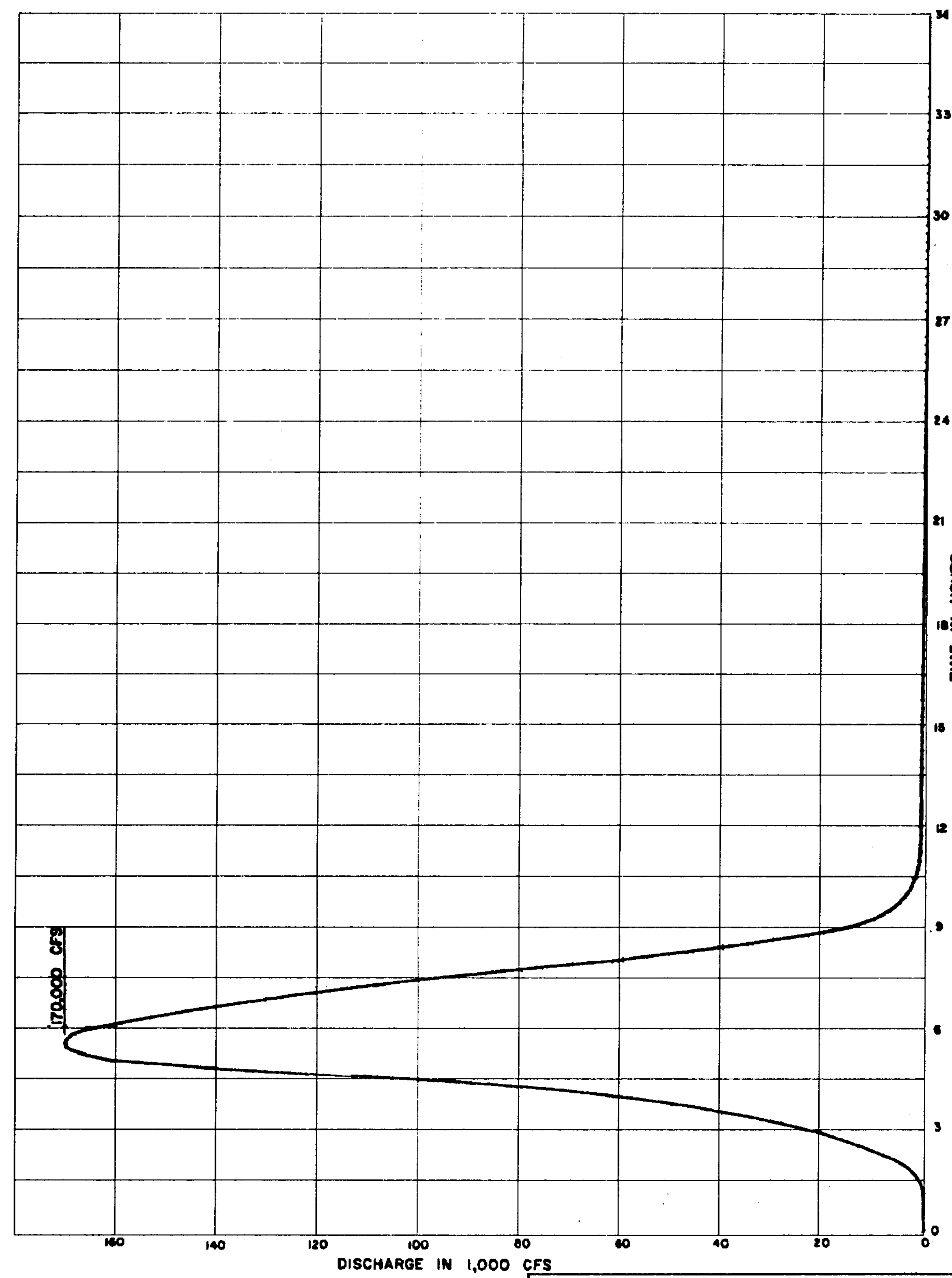
3. DASHED LINES FROM 1 APRIL REPRESENT EXAMPLES OF POSSIBLE SPRING FLOODS.

4. WHEN THE LAKE TRAVERSE AND MUD LAKE POOLS BOTH REACH APPROXIMATELY ELEVATION 976.8 FEET, THE CONTROL FOR LAKE TRAVERSE SHIFTS TO WHITE ROCK DAM. MUD LAKE HAS A CONSERVATION POOL ELEVATION OF 972.0 FEET AND IS NOT REGULATED BELOW THAT LEVEL. SEE CHAPTER 7 AND EXHIBIT D.

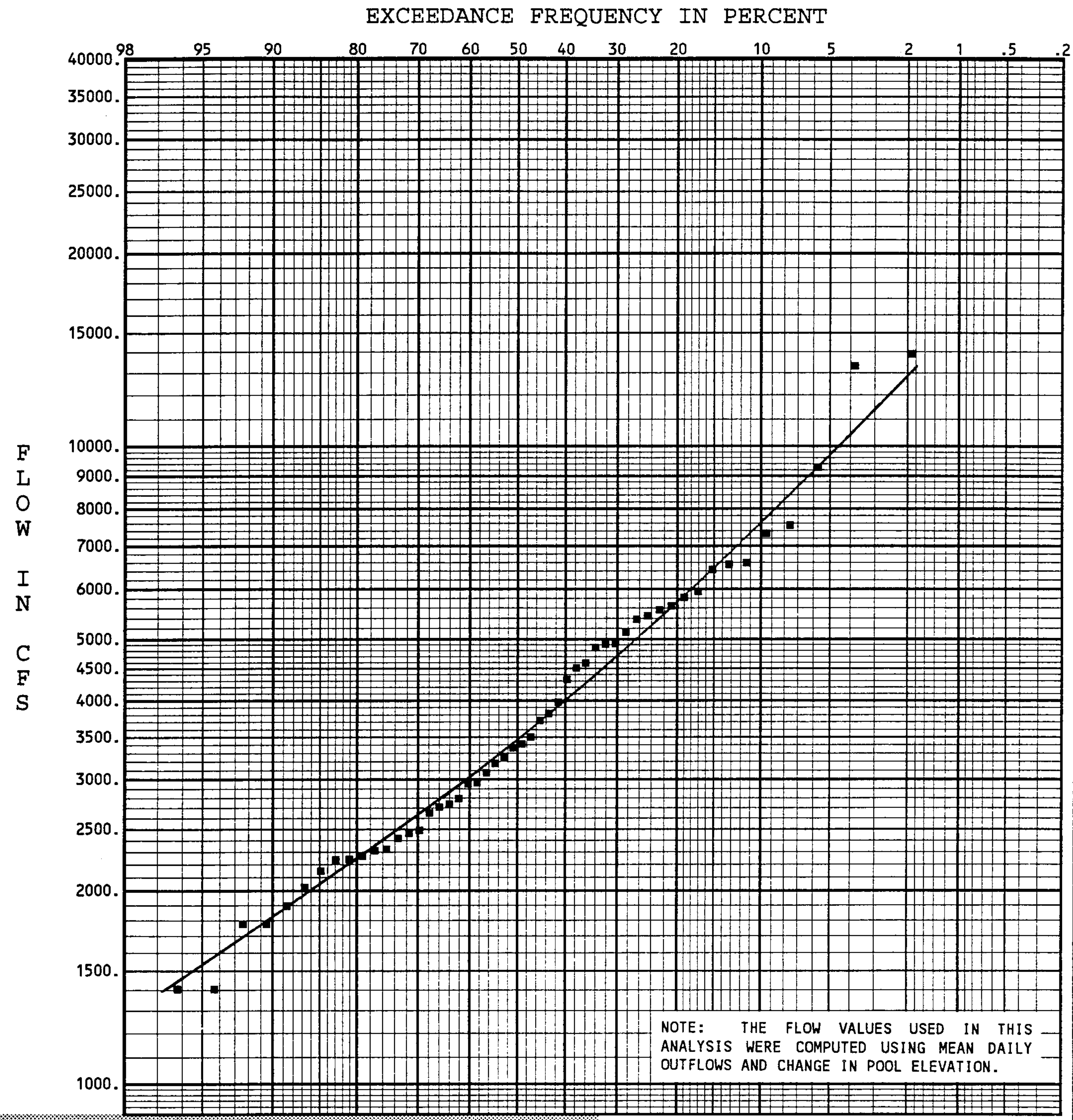
LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

REGULATION SCHEDULE

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL
WHITE ROCK DAM
PROBABLE MAXIMUM FLOOD
AT DAM
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA
Dwg. No. R30-R-5/29



ANNUAL INFLOW-FREQUENCY CURVE

LAKE TRAVERSE PROJECT

WATER YEARS IN RECORD 1942 - 1993

BASIN AREA = 1,160 SQUARE MILES

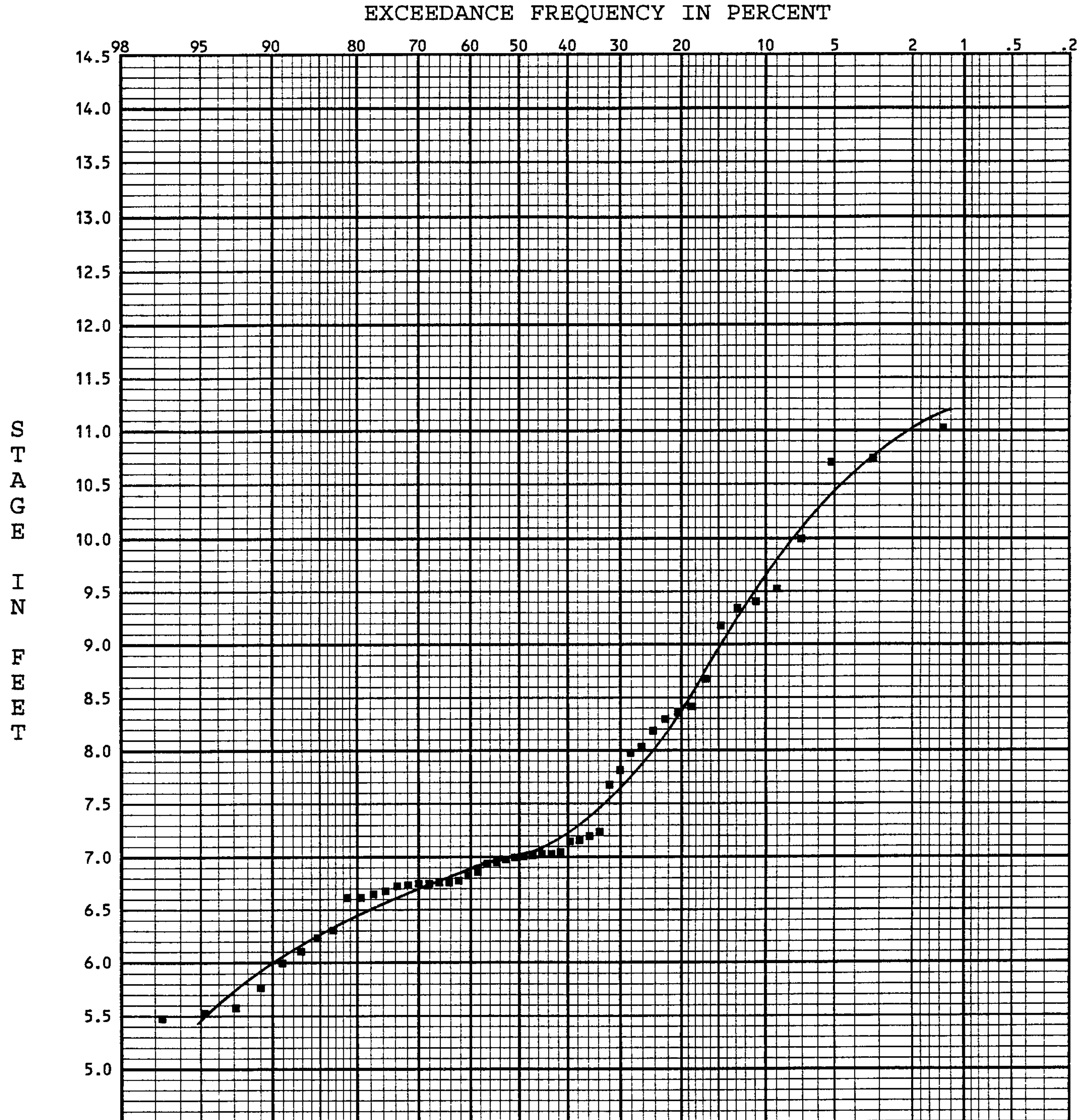
WEIBULL PLOTTING POSITIONS

GRAPHICAL ANALYSIS

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

ANNUAL INFLOW-FREQUENCY
LAKE TRAVERSE PROJECT

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



ANNUAL STAGE-FREQUENCY CURVE

CORPS OF ENGINEERS GAGE

GAGE DATUM IS 970.00 FT MSL (1912 ADJ.)

BASIN AREA = 1,160 SQUARE MILES

WATER YEARS IN RECORD 1942 - 1993

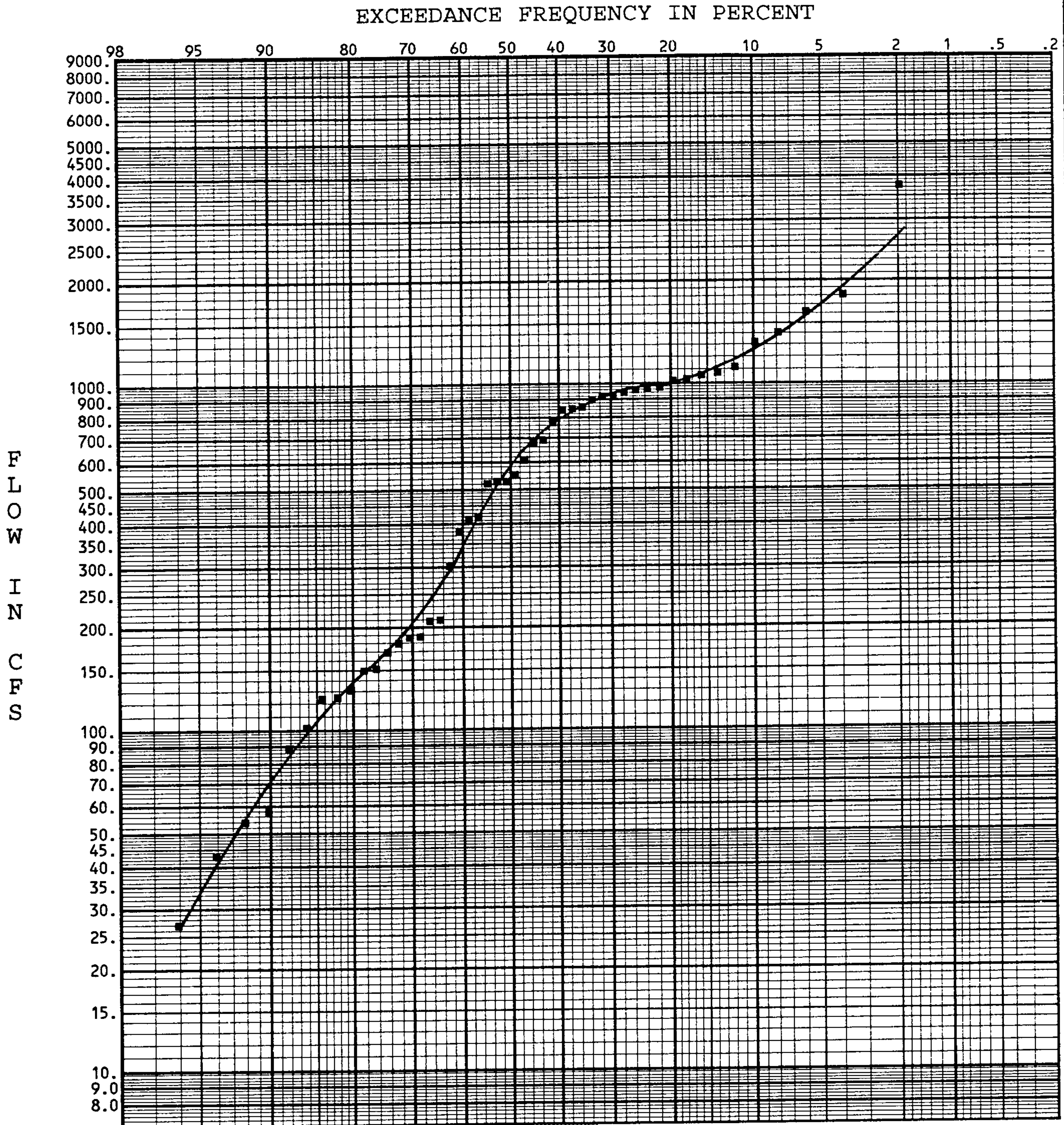
MEDIAN PLOTTING POSITIONS

GRAPHICAL ANALYSIS

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

STAGE-FREQUENCY
LAKE TRAVERSE PROJECT

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



DISCHARGE-FREQUENCY CURVE

ANNUAL INSTANTANEOUS PEAKS

BOIS DE SIOUX RIVER

NEAR WHITE ROCK, SOUTH DAKOTA

USGS GAGE NUMBER 05050000

BASIN AREA = 1,160 SQUARE MILES

WATER YEARS IN RECORD 1942 - 1991

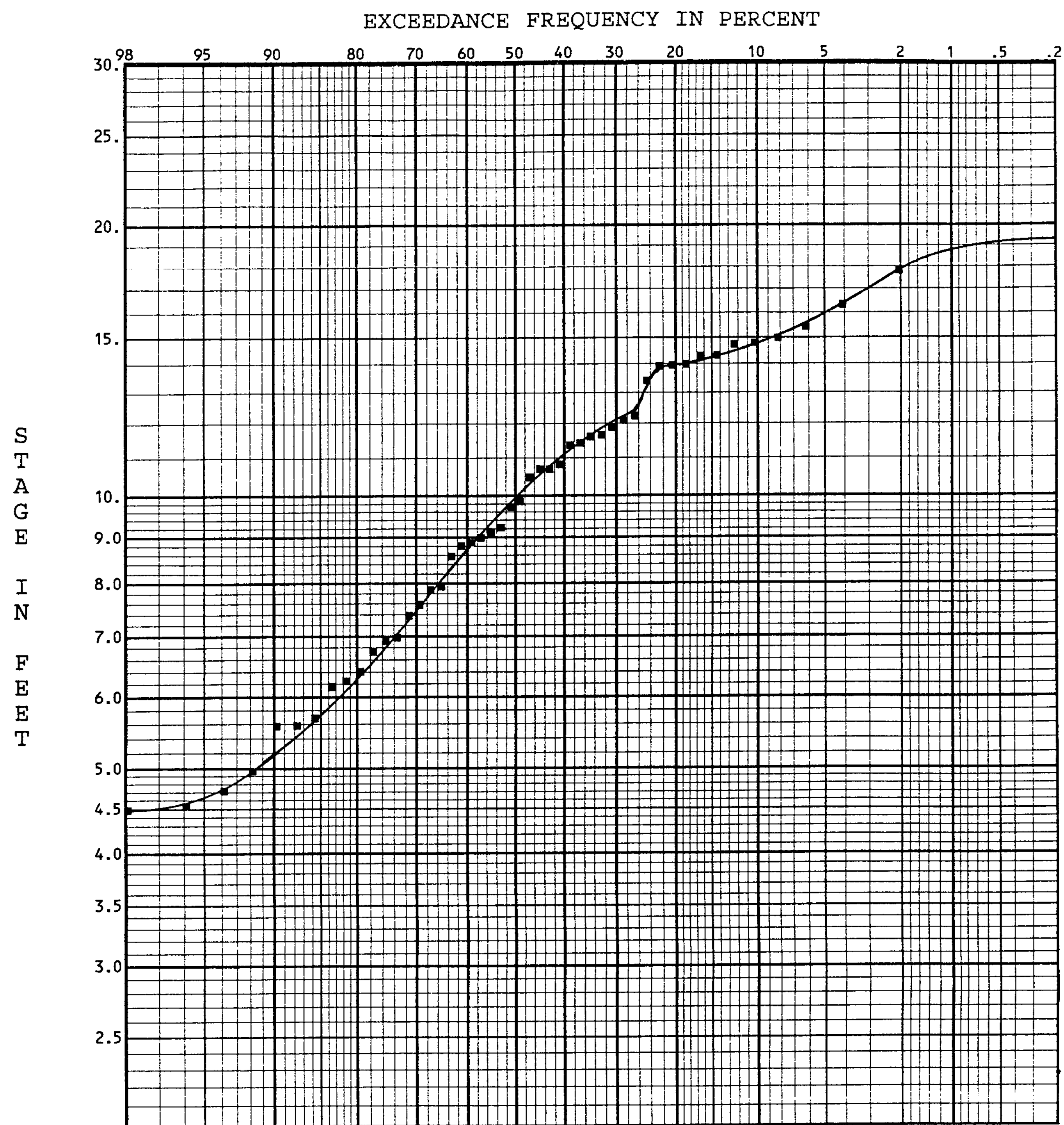
WEIBULL PLOTTING POSITIONS

PLOTTED GRAPHICALLY

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

DISCHARGE-FREQUENCY
U.S.G.S. GAGE NO. 05050000
300 FEET DOWNSTREAM OF
WHITE ROCK DAM

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA



STAGE-FREQUENCY CURVE

ANNUAL INSTANTANEOUS PEAKS

MIXED POPULATION CURVE (ICE AND OPEN WATER EVENTS)

WATER YEARS IN RECORD 1942 - 1989

GAGE ZERO = 942.97 FEET (NGVD 1929)

BASIN AREA = 4,010 SQ MI (1,020 SQ MI EFFECTIVE)

WEIBULL PLOTTING POSITIONS

PLOTTED GRAPHICALLY

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER
WATER CONTROL MANUAL

STAGE-FREQUENCY
U.S.G.S. GAGE NO. 05051500
RED RIVER OF THE NORTH
AT WAHPETON, ND

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA